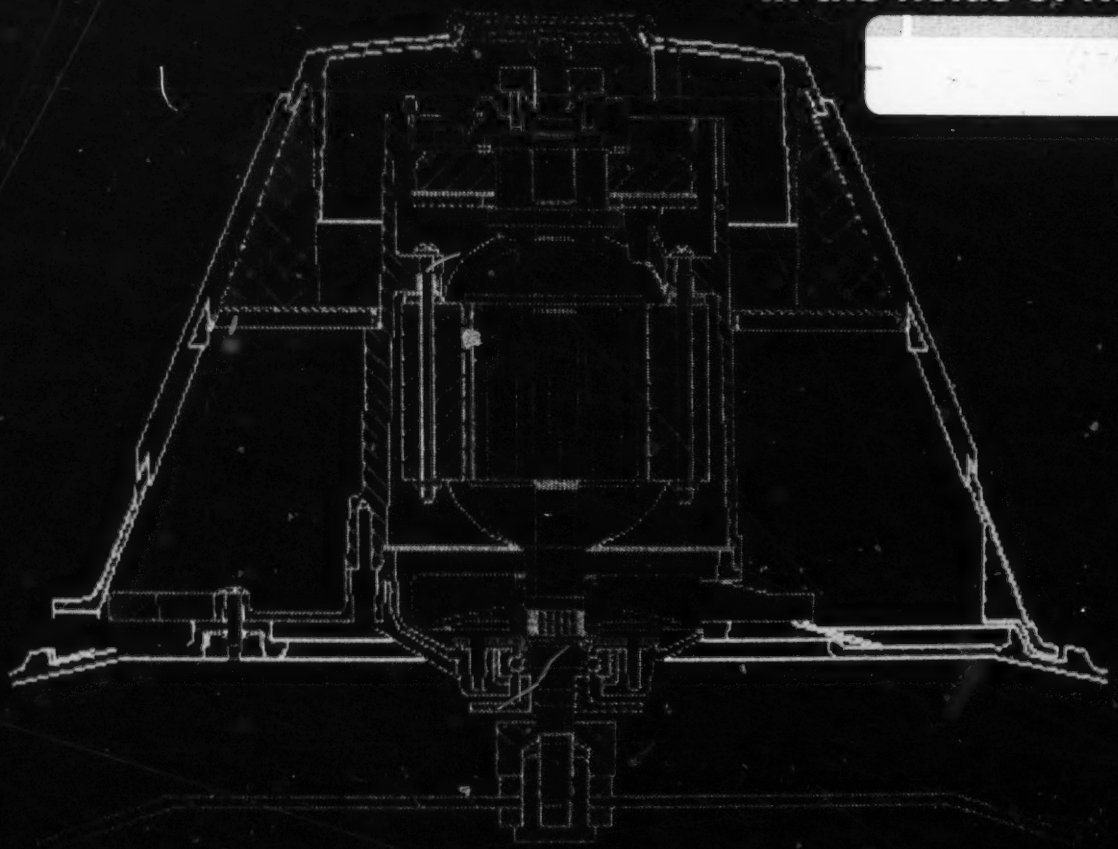
INDUSTRIAL RESEARCH & DEVELOPMENT

NOVEMBER 1983

1983 Scientist of the Year lecture:
Finding gold nuggets in the fields of R&D



color graphics effectively

ical and electronic testing

• in quality assurance

• present instrument uses; plans to acquire

News of importance to people in R&D

Color displays can enhance visualization. See p 105.

INDUSTRIAL RESEARCH & DEVELOPMENT

SERVING THE $156.7-BILLION WORLDWIDE R&D INDUSTRY

EDITORIAL

11 **An industrial policy for the U.S.? No way!**

DEPARTMENTS

17 **Innovative notebook**
25 **Product development**
31 **A lawyer's view**
37 **Research trendletter**
41 **R/D news in brief**
141 **Vacuum technology**
153 **Special new products**
155 **R&D product center**
159 **New products**
171 **Literature**
200 **Bookshelf**
204 **Letters**
206 **Advertisers index**
209 **Reader service card**

ABOUT THE COVER

Color in graphics displays does more than provide another pretty picture. It can help to separate background from foreground, one month's data from another's, temperature or time differences. The choices are almost limitless. Color also can be used to identify hazardous items, different circuits, different sources.

But all of this requires special considerations in the design of the color graphics system. An article on the physiology and psychology of color as applied to color graphics displays begins on p 105.

Cover photo from Tektronix Inc.

Technical Publishing

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ABP BPA

NEWS OF SCIENCE AND TECHNOLOGY

49 **Science policy:** NAS urges that lab waste disposal curbs be eased; Nobel in Medicine recognizes Barbara McClintock's contributions; joint R&D will benefit from relaxed antitrust laws; space shuttle 'comes of age'
51 **Space:** NASA's plans for a space station become a political issue
51 **Measurement:** Laser probes inside chemical reactors
52 **Physics:** U.S. physicists pursue massive SSC collider
54 **Chemistry:** Process provides greater control over polymerization
56 **Electronics:** IBM's 512-kbit chip sets up future marketing battle
56 **Satellites:** IRAS success results from advanced technologies; shelter adds flexibility to Antarctic exploration
62 **Astronomy:** Quasar brightness tied to its gravitational energy; 'unique' pulsar could hold clues about how they form
66 **Propulsion:** Ramjet research soars with component advances; Westinghouse opens plasma development center; wind tunnel will aid design of future shuttles
70 **Conferences:** Labcon experiences another successful year
70 **Awards:** 'Lab of Year' competition begins; *I•R 100* entry forms available
73 **Nuclear:** Swedish method encapsulates nuclear fuel rods in copper
74 **Architecture:** Researchers test 'base isolation' to minimize earthquake damage; pipeline plow wins engineering award

Special Report—Aviation

79 Aircraft R&D brightens industry picture with advances in engine components, airframe design, and increased use of composite materials

ARTICLES

90 **Applied scientist may be standing in field of R&D gold nuggets:** James N. Shoolery, Varian Assoc.; Scientist of the Year says R&D climate helped project.

98 **Thermocouples, RTDs can boost temperature measurement accuracy:** Bob O'Brien and Stephen Miller, John Fluke Mfg. Co.; new tools are accurate.

105 **Good color graphics are a lot more than another pretty display:** Gerald M. Murch, Tektronix Inc.; good graphics consider psychology and physiology.

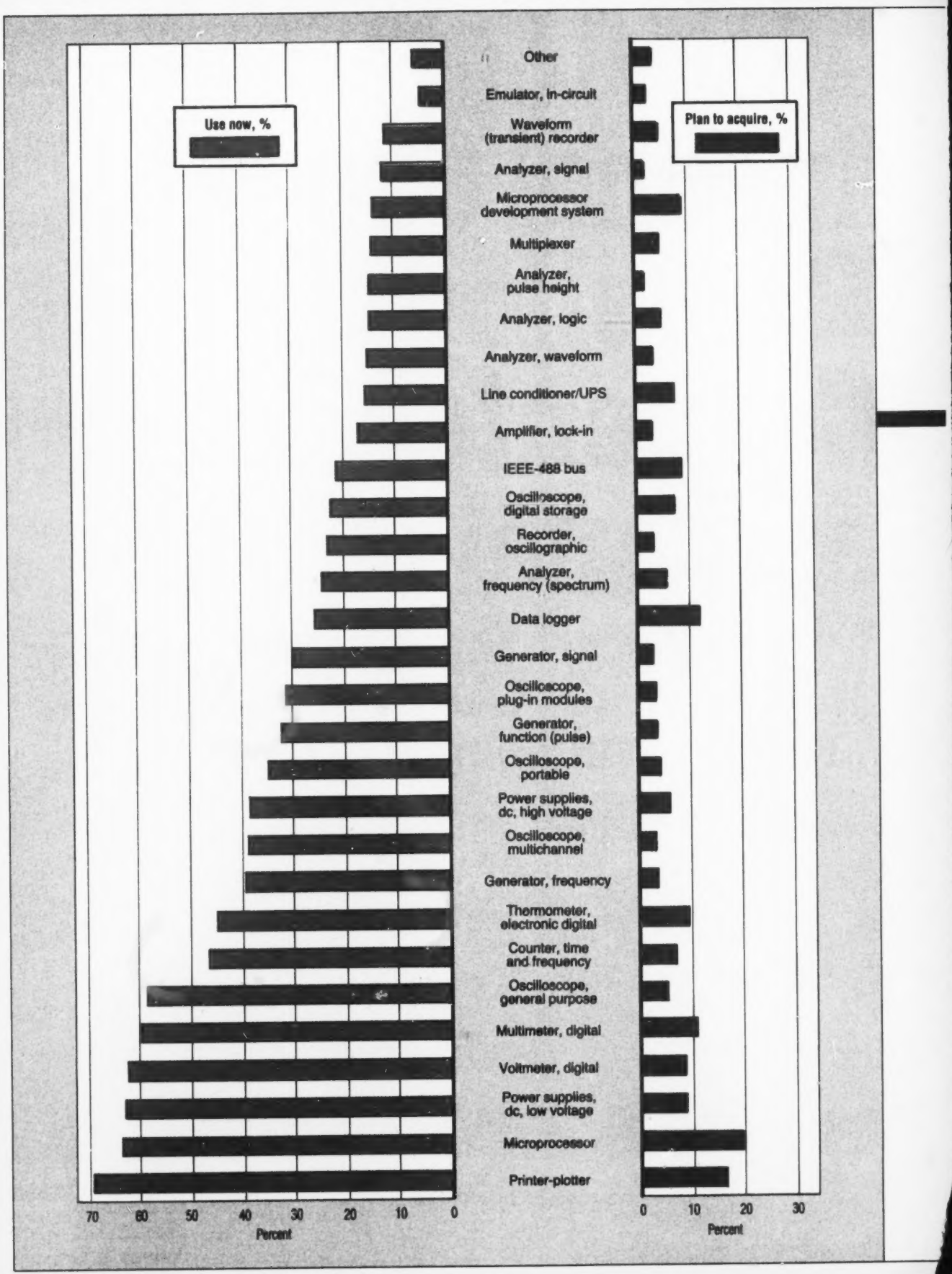
112 **Al casting waste cut by monitoring molten metal cooling curve:** D. Apelian, Drexel Univ., and N.G. Walker, Metallurgical Products & Technologies.

118 **Use of electrical and electronic instruments:** C.J. Mosbacher, executive editor, *IR&D*; industrial R&D plans to acquire fewer instruments this year.

124 **FT-MS uses image current detector to get high mass resolution:** W.D. Bowers, R.L. Hunter, and R.T. McIver Jr., Univ. of California, Irvine.

132 **XRF spectroscopy offers alternative to optical methods:** Gideon Kramer, Kevex Corp.; technique depends on unique characteristics.

141 **Deposition machine uses rodless cylinder to simplify wafer handling:** Jack Dimock, Sputtered Films Inc.; system design provides reliability.


Use now, %
Plan to acquire, %
Other
Emulator, in-circuit
Waveform (transient) recorder
Analyzer, signal
Microprocessor development system
Multiplexer
Analyzer, pulse height
Analyzer, logic
Analyzer, waveform
Line conditioner/UPS
Amplifier, lock-in
IEEE-488 bus
Oscilloscope, digital storage
Recorder, oscillographic
Analyzer, frequency (spectrum)
Data logger
Generator, signal
Oscilloscope, plug-in modules
Generator, function (pulse)
Oscilloscope, portable
Power supplies, dc, high voltage
Oscilloscope, multichannel
Generator, frequency
Thermometer, electronic digital
Counter, time and frequency
Oscilloscope, general purpose
Multimeter, digital
Voltmeter, digital
Power supplies, dc, low voltage
Microprocessor
Printer-plotter
70 60 50 40 30 20 10 0
Percent
0 10 20 30
Percent

C.J. Mosbacher
Executive editor

TRENDSURVEY

Use of electrical and electronic instruments

Plans to acquire new instruments plunge more than 12% according to replies to this year's study, despite somewhat higher plans in the university and science sectors over last year.

WHATEVER GAIN occurred last year in plans to acquire new electrical and electronic instruments for use in R&D will be wiped out in the next year. That's what 1,057 respondents to this year's Trendsurvey tell us with their replies. Average present use this year is 32.2%, and average plans to acquire for 30 instrument categories is 6.2%.

But these numbers cannot be compared directly with results of last year's survey; only 26 instrument categories are the same. Operational amplifiers, universal bridges, analog multimeters, and analog storage oscilloscopes, which were included last year, have been replaced with in-circuit emulators, UPS/line conditioners, multiplexers, and oscillographic recorders in this year's study.

For the 26 unchanged categories, present use this year is 34.9%; last year it was 36.1%. Plans to acquire are 6.6% compared to 7.4% last year.

Still, this does not take into account changes in the demographics from last year to this. When the data are normalized to take this into account, present use for this year rises to 35.5%, which is a drop of 0.65%—less than a 2% change—from last year. But plans to acquire drop almost 1% when normalized, and this is a change of 12.4%.

Thus the Trendsurvey strongly indicates a decrease in instrument acquisitions planned in the next year. Augmenting this indication is an increase of almost 5%—from 44.4% to 46.6%—in the portion of respondents who have no plans to acquire any instruments at all within one year.

The only sector showing a significant increase in plans to acquire is the university, or academic, area. This can be attributed to major increases in Federal funding of research projects, which is also indicated by increased plans in the science sectors. But these are more than offset by diminished plans in the industrial sector and in the engineering disciplines.

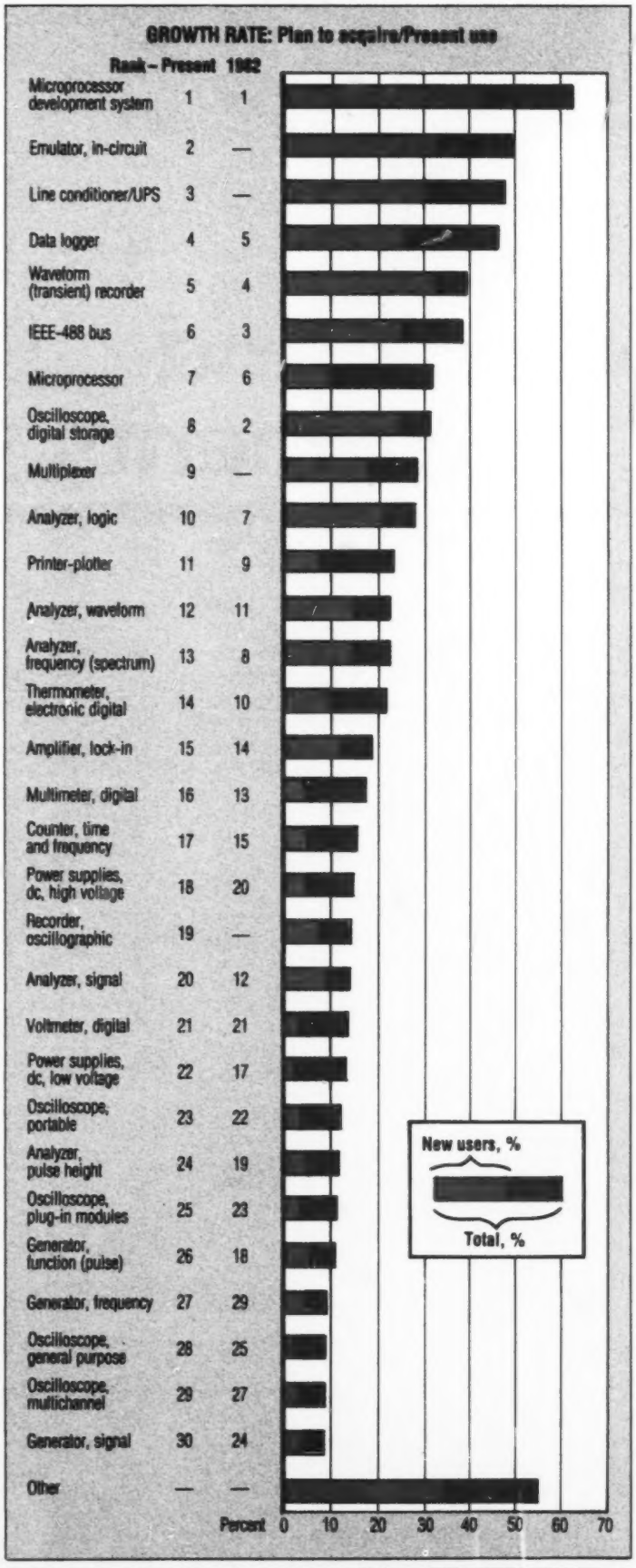
Results of the Trendsurvey are presented graphically on these pages. Present use and plans to acquire are graphed as a percent of the total number of respondents on the first page.

Growth rates calculated with present use of a particular instrument as the base are summarized in the chart on the third page. This chart shows the total growth rate and the rate for new users—those who indicated they do not presently use an instrument but who plan to acquire it in the next year. Rankings this year and last are also given on the growth rate chart.

Complete data giving numbers of respondents as well as percentages for the total sample and disciplines are given in the table on the last page of this article for both growth and growth rate.

Average present use and plans to acquire varied among the demographic groups. The following paragraphs summarize these averages for this year. To provide a means of comparing this year's data with last year's, averages are also given for the 26 instruments that are the same for both years.

By discipline, and without the "Other" category, present use averages 38.9% and plans to acquire average 6.9% for engineering. Comparable figures for physical science are 28.5% and 5.7%, and for life science and medicine 22.6% and 5.8%. For the 26 categories, the corresponding numbers are 41.9% and 7.1%, 31.3% and 6.0%, and


GROWTH RATE: Plan to acquire/Present use
Rank – Present 1982
Microprocessor development system 1 1
Emulator, in-circuit 2 —
Line conditioner/UPS 3 —
Data logger 4 5
Waveform (transient) recorder 5 4
IEEE-488 bus 6 3
Microprocessor 7 6
Oscilloscope, digital storage 8 2
Multiplexer 9 —
Analyzer, logic 10 7
Printer-plotter 11 9
Analyzer, waveform 12 11
Analyzer, frequency (spectrum) 13 8
Thermometer, electronic digital 14 10
Amplifier, lock-in 15 14
Multimeter, digital 16 13
Counter, time and frequency 17 15
Power supplies, dc, high voltage 18 20
Recorder, oscillographic 19 —
Analyzer, signal 20 12
Voltmeter, digital 21 21
Power supplies, dc, low voltage 22 17
Oscilloscope, portable 23 22
Analyzer, pulse height 24 19
Oscilloscope, plug-in modules 25 23
Generator, function (pulse) 26 18
Generator, frequency 27 29
Oscilloscope, general purpose 28 25
Oscilloscope, multichannel 29 27
Generator, signal 30 24
Other — —
New users, %
Total, %
Percent 0 10 20 30 40 50 60 70

24.0% and 6.0% this year, compared to 42.0% and 9.0%, 31.2% and 5.6%, and 22.8% and 4.7% respectively for 1982.

By employer, industry averages 30.8% present use and 5.9% plans to acquire, universities 37.1% and 7.8%, nonprofit organizations 35.9% and 6.6%, medical research centers 26.2% and 6.3%, and other (including government) 31.1% and 5.4%. For the 26 categories, corresponding numbers are 33.3% and 6.2%, 40.5% and 8.4%, 39.0% and 7.2%, 28.2% and 5.8%, and 31.1% and 5.6% this year, compared to 34.2% and 7.3%, 38.4% and 7.2%, 41.4% and 10.1%, 38.5% and 8.9%, and 39.0% and 6.5% for 1982.

Corporate officers have average present use of 32.6% and average plans to acquire of 6.0%, R&D executives 35.0% and 9.2%, project managers 34.5% and 7.3%, professional staff 31.8% and 5.7%, and other 28.4% and 4.9%. For the 26 comparable categories, the corresponding numbers are 34.9% and 6.3%, 37.4% and 9.8%, 37.4% and 7.6%, 34.6% and 6.0%, and 31.6% and 5.3% this year, and 36.4% and 10.7%, 33.5% and 10.1%, 39.9% and 9.1%, 34.7% and 6.7%, and 40.7% and 7.1% for 1982.

As is to be expected, the demographics of respondents vary from year to year. In this year's survey, 3.0% are corporate officers, 7.0% R&D executives, 17.1% project managers, 66.3% professional staff, and 4.2% other. Last year, the corresponding numbers were 4.3%, 7.3%, 15.8%, 65.7%, and 5.8%. Note that the totals are less than 100% because some respondents did not answer all questions.

By discipline, 43.6% of this year's respondents gave engineering as their primary discipline, 40.7% physical science, and 12.2% life science or medicine. The corresponding 1982 figures were 52.6%, 35.7%, and 9.3% respectively. Thus there was a significant shift toward the sciences.

Slightly less of a shift occurred from industry to the academic and nonprofit areas. This year, 52.6% of respondents work in industry, 19.6% in universities, 7.4% in nonprofit organizations, 2.6% in medical research centers, and 14.9% elsewhere. In 1982, the corresponding numbers were 57.8%, 18.6%, 6.3%, 2.4%, and 12.3%.

In geographic terms, the distribution of respondents once again correlates well with the *IR&D* circulation, which in turn correlates with R&D activity in the United States. New England accounts for 7.2% of respondents, Middle Atlantic 15.3%, East North Central 18.8%, West North Central 5.3%, South Atlantic 13.0%, East South Central 3.5%, West South Central 6.6%, Mountain 5.1%, and Pacific 16.6%. No answer was provided by 8.6% of respondents.

As with earlier Trendsurveys, this study was conducted by including a prepaid reply postcard in a mailing to domestic *IR&D* subscribers. The mailing was done in late May, and by early August, 1,057 cards that provided the data included here had been returned. □

PRESENT AND PLANNED USE: Data from 1,057 respondents

	Use now								Plan to acquire within 1 year								Growth rate = plan to acquire ÷ by present use			
	Total, 1,057		Engineering, 461		Physical science, 430		Life science or medicine, 129		Total, 1,057		Engineering, 461		Physical science, 430		Life science or medicine, 129		Total	Present users who plan to acquire		New users
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	%	No.	%	%
Amplifier, lock-in 1982	179	16.9 17.8	68	14.8	87	20.2	21	16.3	32	3.0 3.3	9	2.0	20	4.7	3	2.3	17.9	12	6.7	11.2
Analyzer, frequency (spectrum) 1982	258	24.4 23.2	155	33.6	84	19.5	12	9.3	58	5.5 6.3	35	7.6	20	4.7	1	0.8	22.5	22	8.5	14.0
Analyzer, logic 1982	154	14.6 14.4	98	21.3	38	8.8	10	7.8	43	4.1 4.8	27	5.9	8	1.9	7	5.4	27.9	11	7.1	20.8
Analyzer, pulse height 1982	154	14.6 14.0	52	11.3	83	19.3	13	10.1	18	1.7 2.0	5	1.1	10	2.3	3	2.3	11.7	11	7.1	4.5
Analyzer, waveform 1982	159	15.0 15.3	92	20.0	56	13.0	8	6.2	36	3.4 3.3	22	4.8	11	2.6	1	0.8	22.6	13	8.2	14.5
Analyzer, signal 1982	135	12.8 16.2	73	15.8	48	11.2	10	7.8	18	1.7 3.3	11	2.4	5	1.2	2	1.6	13.3	6	4.4	8.9
Counter, time and frequency 1982	492	46.5 49.9	275	59.7	161	37.4	42	32.6	75	7.1 8.7	42	9.1	22	5.1	9	7.0	15.2	48	9.8	5.5
Data logger 1982	275	26.0 26.0	152	33.0	100	23.3	16	12.4	125	11.8 11.0	61	13.2	44	10.2	17	13.2	45.5	51	18.5	26.9
Emulator, in-circuit 1982	49	4.6 —	36	7.8	8	1.9	3	2.3	24	2.3 —	16	3.5	3	0.7	4	3.1	49.0	8	16.3	32.7
Generator, frequency 1982	421	39.8 45.2	249	54.0	130	30.2	30	23.3	38	3.6 4.0	22	4.8	11	2.6	5	3.9	9.0	21	5.0	4.0
Generator, function (pulse) 1982	339	32.1 35.6	195	42.3	114	26.5	23	17.8	36	3.4 5.3	25	5.4	9	2.1	2	1.6	10.6	17	5.0	5.6
Generator, signal 1982	316	29.9 34.5	186	40.3	98	22.8	21	16.3	27	2.6 3.8	15	3.3	8	1.9	4	3.1	8.5	15	4.7	3.8
IEEE-488 bus 1982	227	21.5 20.5	120	26.0	91	21.2	10	7.8	86	8.1 9.3	42	9.1	34	7.9	6	4.7	37.9	30	13.2	24.7
Line conditioner/UPS 1982	163	15.4 —	79	17.1	57	13.3	23	17.8	77	7.3 —	36	7.8	29	6.7	10	7.8	47.2	28	17.2	30.1
Microprocessors 1982	670	63.4 56.6	306	66.4	275	64.0	76	58.9	209	19.8 20.3	87	18.9	87	20.2	26	20.2	31.2	148	22.1	9.1
Microprocessor development systems 1982	149	14.1 15.8	85	18.4	49	11.4	10	7.8	92	8.7 8.8	43	9.3	31	7.2	12	9.3	61.7	31	20.8	40.9
Multimeter, digital 1982	633	59.9 69.2	329	71.4	246	57.2	45	34.9	107	10.1 13.2	57	12.4	37	8.6	12	9.3	16.9	80	12.6	4.3
Multiplexer 1982	150	14.2 —	88	19.1	46	10.7	11	8.5	43	4.1 —	22	4.8	15	3.5	5	3.9	28.7	16	10.7	18.0
Oscilloscope, digital storage 1982	240	22.7 18.4	142	30.8	74	17.2	15	11.6	74	7.0 8.8	45	9.8	21	4.9	7	5.4	30.8	17	7.1	23.8
Oscilloscope, general purpose 1982	618	58.5 60.0	315	68.3	231	53.7	55	42.6	54	5.1 6.3	24	5.2	25	5.8	5	3.9	8.7	39	6.3	2.4
Oscilloscope, multichannel 1982	411	38.9 43.9	243	52.7	121	28.1	31	24.0	35	3.3 4.3	21	4.6	12	2.8	2	1.6	8.5	22	5.4	3.2
Oscilloscope, plug-in modules 1982	327	30.9 36.1	187	40.6	103	24.0	25	19.4	36	3.4 4.0	14	3.0	19	4.4	2	1.6	11.0	24	7.3	3.7
Oscilloscope, portable 1982	368	34.8 35.9	214	46.4	116	27.0	25	19.4	44	4.2 4.6	21	4.6	17	4.0	5	3.9	12.0	29	7.9	4.1
Power supplies, dc, high voltage 1982	406	38.4 40.7	176	38.2	169	39.3	49	38.0	60	5.7 5.8	23	5.0	26	6.0	10	7.8	14.8	42	10.3	4.4
Power supplies, dc, low voltage 1982	669	63.3 66.7	342	74.2	239	55.6	69	53.5	87	8.2 10.7	42	9.1	31	7.2	12	9.3	13.0	68	10.2	2.8
Printer-plotters 1982	737	69.7 64.2	309	67.0	318	74.0	87	67.4	170	16.1 16.4	70	15.2	70	16.3	23	17.8	23.1	115	15.6	7.5
Recorder, oscillographic 1982	246	23.3 —	150	32.5	60	14.0	32	24.8	33	3.1 —	18	3.9	11	2.6	4	3.1	13.4	14	5.7	7.7
Thermometer, electronic digital 1982	476	45.0 46.1	245	53.1	181	42.1	37	28.7	102	9.6 10.0	45	9.8	43	10.0	11	8.5	21.4	55	11.6	9.9
Voltmeter, digital 1982	661	62.5 59.1	336	72.9	253	58.8	55	42.6	87	8.2 7.7	40	8.7	34	7.9	11	8.5	13.2	66	10.0	3.2
Waveform (transient) recorder 1982	127	12.0 13.1	76	16.5	39	9.1	9	7.0	50	4.7 5.9	28	6.1	17	4.0	4	3.1	39.4	9	7.1	32.3
Other 1982	64	6.1 6.3	28	6.1	24	5.6	11	8.5	35	3.3 2.2	20	4.3	12	2.8	2	1.6	54.7	13	20.3	34.4

Research & Development

formerly INDUSTRIAL RESEARCH & DEVELOPMENT

JANUARY 1984

Our forecast for R&D funding through 1984

Materials and technology in communications

News of value to people who work in R&D

Research & Development

SERVING THE $186 BILLION WORLDWIDE R&D INDUSTRY

Multiregion scans and depth profiles in ESCA. See p 80.

EDITORIAL

11 The changing role of industrial research and development

DEPARTMENTS

17 Innovative notebook
29 Product development
33 A lawyer's view
37 Research trendletter
41 R/D news in brief
109 Vacuum technology
117 New products
123 Literature
130 R&D product center
140 Bookshelf
144 Opinion poll questionnaire
147 Letters
154 Advertisers index
157 Reader service card

ABOUT THE COVER

We may not be operating in outer space as this unit appears to be, but we do need a good vacuum when we use ESCA (photoelectron spectrometry) techniques. Use of photoelectric effects permits chemical analysis of the top few layers of solids.

A recent *I•R 100* award winner is an improved spectrometer that features a small spot size and monochromatic x rays. The small spot size lets analysts study small features that would be damaged by electron beam analysis. See article beginning on p 80.

Cover photo courtesy Surface Science Laboratories Inc.

NEWS

47 Space: NASA plans a busy year for the shuttle; U.S., Soviet setbacks show vulnerabilities of manned space flight; new equipment advances high-energy physics

49 Science policy: 'Industrial policy could play a pivotal role in electronics'; tough Reagan rhetoric is lost in technology export actions

56 Electronics: Molecular computers generate interest and skepticism; British researchers pursue molecular electronics

58 Environment: Greenhouse Effect is real, but need for concern remains clouded

62 Superconductivity: Research unveils complexities of organic superconductors; British foresee a big role for LEP

64 R&D industry: Study shows many surprises in high tech industry siting and growth

66 Awards: U.S. scientists make a clean sweep of Nobel science prizes; Lab of Year deadline nears; *I•R 100* Program rewards innovator's hard work

ARTICLES

73 In what ways will the AT&T breakup affect the R&D scientist? Gary Parr, assistant editor, interviews Kevin Sara, Northern Business Information Inc., and Prof. Stephen Ross, Yale Univ.

77 Funds for R&D will reach almost $98 billion in 1984: C.J. Mosbacher, executive editor; part of the increase results from NSF adjustments to data.

80 More-powerful ESCA makes solving surface problems a lot easier: M.A. Kelly, Surface Science Laboratories; hardware enhances speed and usefulness.

86 Toss your keyboards and just tell your computer what to do: Ann Conrad, Votan; voice technology speeds data entry and improves productivity.

92 How many people listened to your call? Gregg Booth, Controlonics Corp.; telephone message scrambling devices can provide security for R&D.

96 Computer network promotes education and physics R&D: Thomas Meyer, Texas A&M Univ.; dual supermini-based network computes on campus and off.

102 Ruthenium contacts resist chemical attack in communications use: R.D. Lanam and A.R. Robertson, Engelhard Corp.; sputter films in contacts, barriers.

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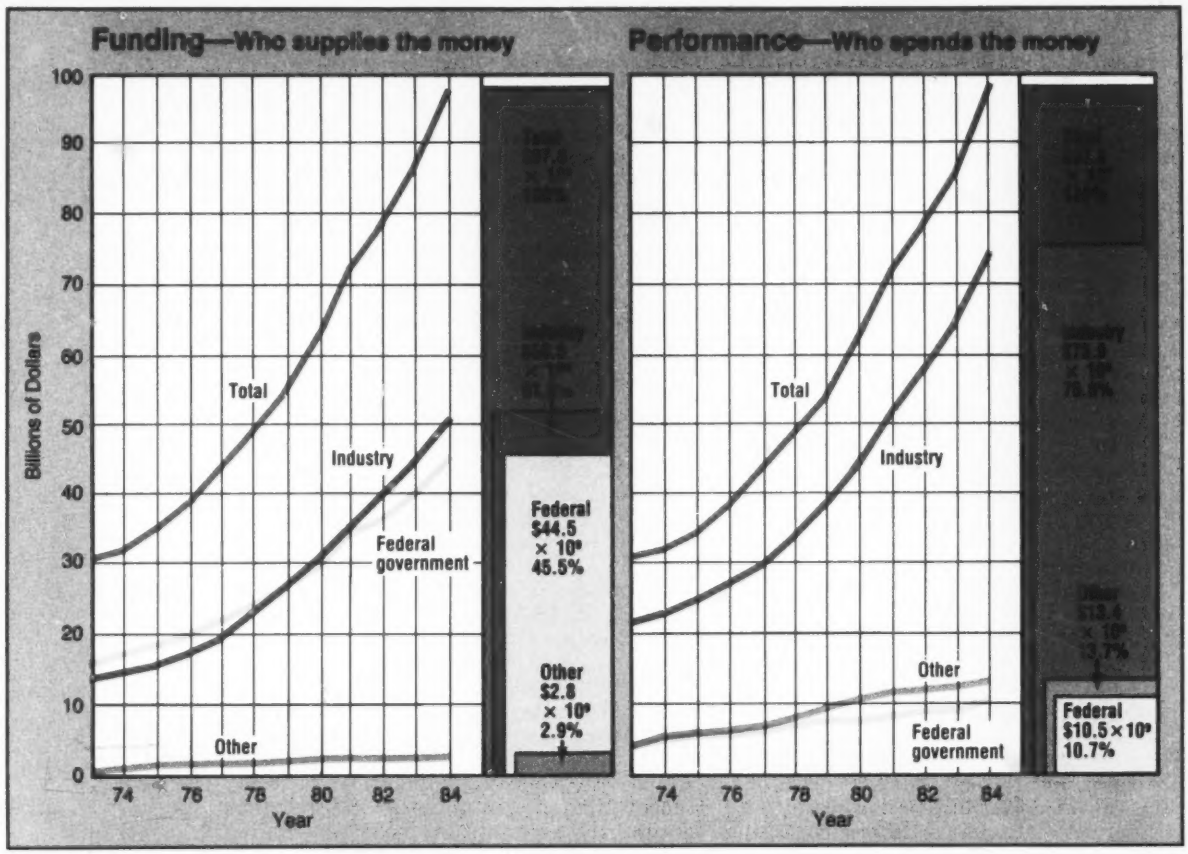

Funds for R&D will reach almost $98 billion in 1984

Our annual forecast predicts R&D spending of $97.8 billion in 1984. But part of the apparent increase stems from adjustments to earlier data and their interpretation.

C.J. Mosbacher
Executive editor

AT FIRST GLANCE, the graphs at the top of this page indicate an enormous increase in R&D funding in the United States from 1983 to 1984. Actually, you are looking at an anomaly. The funds will be available—some $97.8 billion if our forecast is right—but the increase from earlier years is smaller than the graphs would indicate.

To understand why, we have to go back several years and examine funding provided by the Federal government and by industry. The data through 1983 in the graphs come from a National Science Foundation publication, "Science Resources Studies Highlights," NSF 83-316, dated July 22, 1983. Many of the adjustments to earlier data have already been made in these latest NSF statistics on R&D funding. For example, NSF's estimate of Federal government funding for 1983 now is $39.63 billion, significantly higher than the $39.2 billion in our forecast of 1983 funds (*R&D*, January 1983).

We had expected late Congressional appropriations to keep Federal funding well below budgeted levels. Instead, Congress used a continuing resolution to replace appropriation bills for a significant portion of R&D—in effect providing more money earlier. Thus the various government departments were able to obligate funds at an earlier time than we expected, resulting in an increase in Federal funds spent in 1983.

NSF 83-316 also adjusts Federal funding data for earlier years: down from $30 to $29.7 billion in 1980; up from $32.9 to $33.8 billion in 1981; and up from $36.1 to $36.6 billion in 1982. The data for 1982

and 1983 are labeled as estimates.

More significant are the revisions to industry funding levels. In 1981, these increased from $34.4 to $35.9 billion; in 1982, the increase is from $38.0 to $40.0 billion; and in 1983, from $41.7 to $44.3 billion. But even these increases do not reflect all of the increases that are to be made. Preliminary indications are that additional corrections will be made for 1981 and succeeding years as final data from Bureau of Census surveys of industry and other sources are compiled.

The National Science Foundation was not alone in underestimating industry funding for this period. For 1980, for example, we predicted a 12.5% increase over the preceding year, and for 1981, an increase of 14.3%. The Economics Dept. of McGraw-Hill Publications Co. recently reported that R&D spending by industry increased more than 16% in each of these years. This tends to confirm the need for further revisions in the NSF data. We shall discuss this point further in a later section.

For now, as in previous forecasts, we should note that the NSF data for 1983 being used as the basis for this forecast are that industry provided $44.3 billion for R&D and spent $64.3 billion in the performance of R&D, with the difference coming from Federal funds. Federal funding was $39.6 billion; performance, $9.7 billion. Academic and other nonprofit organizations provided $2.6 billion and spent $12.5 billion, with most of the difference coming from Federal funding, although industry funding of this sector has increased.

NSF 83-316 also provides estimates of 1984 funding that total $97 billion. This includes $44.5 billion from the Federal government, which will perform $10.5 billion of R&D in its own facilities. Industry will provide $49.8 billion and spend $73.3 billion. Academic and other nonprofit organizations will provide $2.8 billion and spend $13.2 billion.

The principal difference between these NSF projections and our forecast lie in funding provided by industry for its own R&D and for projects it supports in academic and other nonprofit organizations. This will be discussed as we consider each sector in turn.

Why industry data are revised. As noted earlier, NSF and *R&D* forecast data for 1980 and 1981 underestimated industry funding. While some revisions have been made because of this, we feel that 1982 funding by industry is still understated. We therefore have increased 1982 industry funding to an estimated $41.7 billion, some 16.3% above 1981, and projected 1983 industry funding as just under $45.1 billion.

Thus, although a 14% increase over 1983 is indicated against the NSF data, an increase of just under 12% from the revised 1983 base leads to our forecast of $50.5 billion for industry funding in 1984. Similarly, industry performance of R&D will rise to $73.9 billion, almost 15% over the 1983 NSF base but less than 12% from the revised base.

Part of this projection rests on defense funding increases by the Federal government being larger than other Federal funding increases. Most of defense R&D spending goes to industry efforts. Another part of the projection tends to lower industry funds that are spent by industry: More industry funds are going to the academic sector and to nonprofit industrial research groups in such areas as semiconductor manufacturing and computer science.

Industry funding of $50.5 billion would be 51.6% of all R&D funds available in the United States in 1984. At $73.9 billion, industry would be spending 75.6% of all the available funds.

Federal funding surer for 1984. One of the pleasant surprises in the 1984 Federal budget has been significant increases in the amounts requested from Congress for basic research. These almost double the increases of the last few years and will provide at least 6% more funds for basic research in 1984.

But this pales when compared to the 28% increase in the budget for national defense R&D funding (note, however, that much of the basic research funding increase is included there). Transportation R&D gets a 22% increase in the budget; general science programs, 15%; health, 3%; and space a slight increase. But R&D devoted to natural resources and the environment are scheduled for a 15% decline; energy for an 11% decrease.

Overall the budget for fiscal 1984 called for $45.7 billion. Congress has appropriated virtually all the defense funds requested in the budget and has not significantly changed funding levels overall, although it has rearranged priorities for spending in such appropriations as that for the National Institutes of Health. We project that Federal government funding will provide $44.5 billion in 1984, or 45.5% of total funding. We also project that Federal laboratories will spend $10.5 billion, or 10.7% of the total. This amounts to a 12.4% increase in funding and a 7.2% increase in performance over 1983.

Universities and nonprofits match gain. In performance, the academic and nonprofit sectors also will experience a 7.2% gain from 1983, with $13.4 billion spent on R&D for 13.7% of the total.

Funding provided by this sector will increase slightly more—some 7.7%—to $2.8 billion. Actually, part of this apparent increase is due to rounding; a better figure would be $2.75 billion, or a 6.2% increase. This is about 2.9% of total funding.

In summary, some might consider a forecast of a 12% increase in R&D funding for 1984 optimistic, as it implies, with 5% inflation, real growth of 7%. We feel that the projections are realistic and will be reached, barring any catastrophe in the overall economy. R&D

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Pittsburgh Conference issue: more to see, hear, do at P-Con

Combine x ray and IR to assure paints with correct pigment values

Trendsurvey: uses of analytical instruments and equipment—1984

Instruments and technology for analytical chemistry

News of importance to people who work in research, development

Research & Development

SERVING THE $186-BILLION WORLDWIDE R&D INDUSTRY

Quality assurance of pigments for protective coatings. **See p 124.**

EDITORIAL

11 Like your job? Congress helps those who help themselves.

DEPARTMENTS

17 Innovative notebook
25 Product development
33 A lawyer's view
41 Research trendletter
45 R/D news in brief
183 Vacuum technology
197 New products
211 R&D product center
221 Literature
242 Bookshelf
248 Opinion poll questionnaire
253 Letters
258 Advertisers index
261 Reader service card

ABOUT THE COVER

In the protective coating industry, pigments often are supplied as pastes based on a vehicle that is compatible with the base polymer used. The amount of pigment present in the pastes is an important indication of both the protective capability and the hiding power (opacity) of an applied coating.

Today, the quality control of paints and coatings involves the spectroscopic examination for pigment content. A related article begins on p 124.

Cover photo by Gary L. Parr, *R&D* assistant editor.

NEWS

53 Space: U.S. is losing ground in space; Reagan space decisions draw fire; fusion breakeven conditions achieved

55 Astronomy: Submillimeter telescope; advanced instruments aid astronomy; laser probes inside engines

62 Artificial intelligence: satellite autonomy spurs 'Expert' system research

68 Cryogenics: Supercooling with solar heat; unattended power generator

70 Science policy: U.S. agencies dispute computer shipment; quake rumbles softened; Australian technology policy

76 Robotics: Improved robot dexterity; . . . precision; . . . vision

80 Aviation: New look in cockpits; propfans exploit fuel economy

82 Awards: Last call for *I•R 100* entries

84 Superconductivity: Organic superconductor research; seismic simulator

88 Imaging: Radar views Earth from space

91 Resources: Iceberg for power generation

92 Physics: Team probes naked nuclei

92 Energy and power: Theories of coal formation; Israelis utilize oil shale

95 R&D industry: Pulling U.S. out of rut

96 Lasers: Researchers advance KrF lasers

Special Report—Computer Processing
101 Complex scientific problems are forcing a change in the way computers compute

ARTICLES

120 Should the U.S. have a national industrial policy? Lester Thurow, MIT; Philip Trezise, Brookings Institute

124 Combine x-ray and IR methods to assure paint pigment value: J.R. Carter, *et al.*, NL Industries Inc.

132 Scandium anode lets side-window x-ray tube find light elements: J.N. Kikkert, N.V. Philips.

138 Cut hazards of flammable liquids: A.M. Stevens, Justrite Mfg. Co.

145 1984 Pittsburgh Conference: C.J. Mosbacher, executive editor, *R&D.*

150 PC handles chromatography data: G.I. Ouchi, Nelson Analytical.

156 Uses of analytical instruments and equipment, 1984: C.J. Mosbacher, *R&D.*

162 High-temp spectrophotometer: V. Rossiter, Accuspec Ltd.

168 High R&D involvement in quality assurance: Opinion Poll results.

172 Vacuum monochromator with ICP for hidden elements: D.D. Nygaard, *et al.*, Allied Analytical Systems.

178 Capillary GC aids process control: G. Walden, Proctor & Gamble Co.

183 MO-CVD technology improves: J.E. Andrews, Research Triangle Institute.

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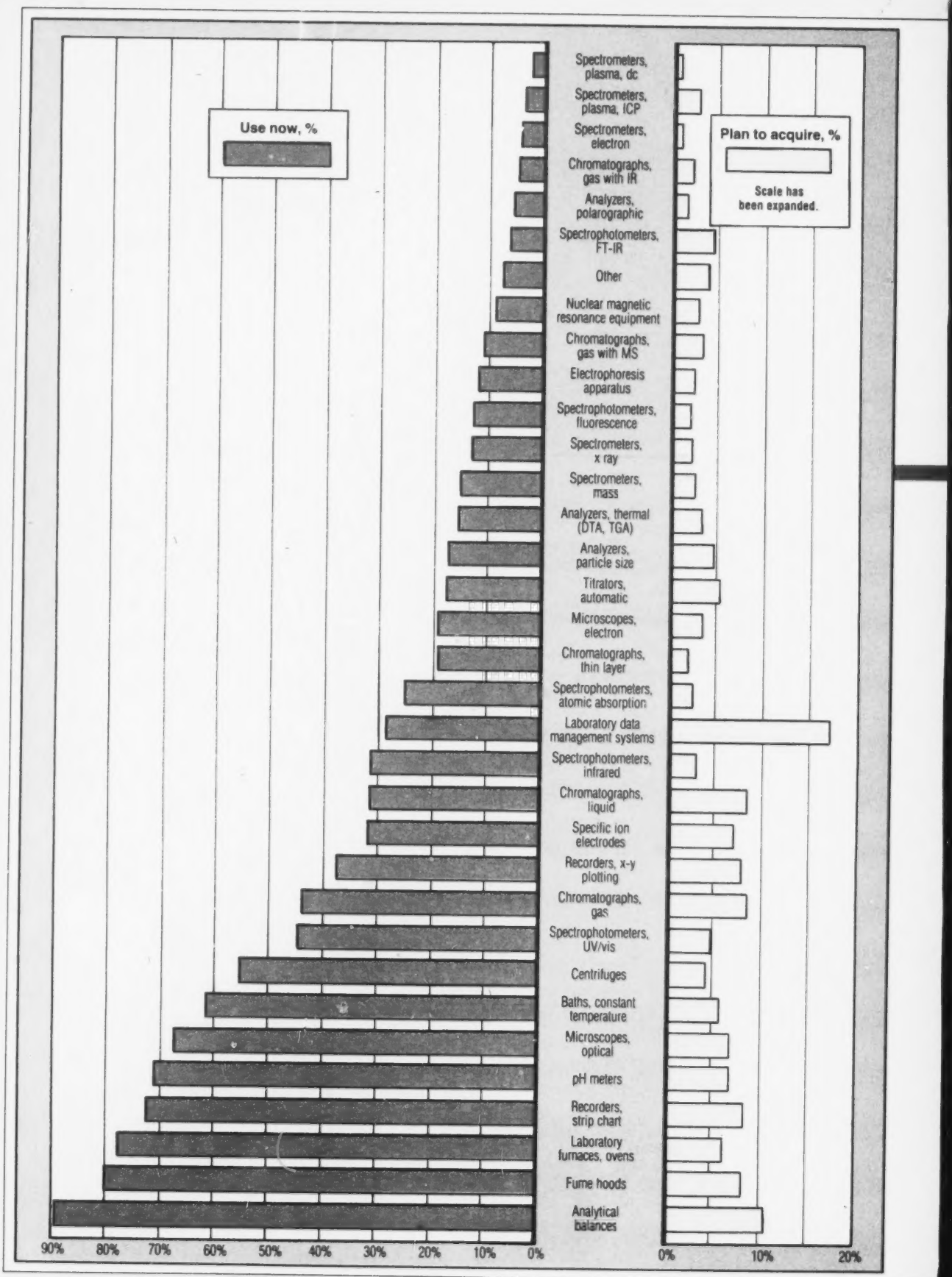

Use now, %
Plan to acquire, %
Scale has been expanded.
Spectrometers, plasma, dc
Spectrometers, plasma, ICP
Spectrometers, electron
Chromatographs, gas with IR
Analyzers, polarographic
Spectrophotometers, FT-IR
Other
Nuclear magnetic resonance equipment
Chromatographs, gas with MS
Electrophoresis apparatus
Spectrophotometers, fluorescence
Spectrometers, x ray
Spectrometers, mass
Analyzers, thermal (DTA, TGA)
Analyzers, particle size
Titrators, automatic
Microscopes, electron
Chromatographs, thin layer
Spectrophotometers, atomic absorption
Laboratory data management systems
Spectrophotometers, infrared
Chromatographs, liquid
Specific ion electrodes
Recorders, x-y plotting
Chromatographs, gas
Spectrophotometers, UV/vis
Centrifuges
Baths, constant temperature
Microscopes, optical
pH meters
Recorders, strip chart
Laboratory furnaces, ovens
Fume hoods
Analytical balances
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
10%
20%

TRENDSURVEY

Uses of analytical instruments and equipment, 1984

Planned acquisitions of newer types of instruments and equipment raise the index from last year, but after normalization for demographic changes, plans to acquire older types stay just about the same.

C.J. Mosbacher
Executive editor

WILL SCIENTISTS and engineers add more analytical instruments and equipment to their laboratories this year than in 1983? If you consider the raw data—that average present use dropped from 32.5 to 31.7% of respondents while plans to acquire rose from 4.6 to 4.97%—your answer would have to be yes. That would be reinforced by a drop in those with no plans to acquire within one year, from 47.7% of respondents in 1983 to 41.0% this year. But you could be wrong because of several other factors.

The largest factor is the dropping of three categories—automated wet chemistry analyzers, oxygen analyzers, and microchemical apparatus—that appeared last year, and their replacement by three new categories—gas chromatographs with IR, FT-IR spectrophotometers, and laboratory data management systems. The three old categories averaged 13.8% in present use and 2.17% in plans to acquire. Their elimination raises average present use for last year to 34.39% and average plans to acquire to 4.85% for the 30 categories left.

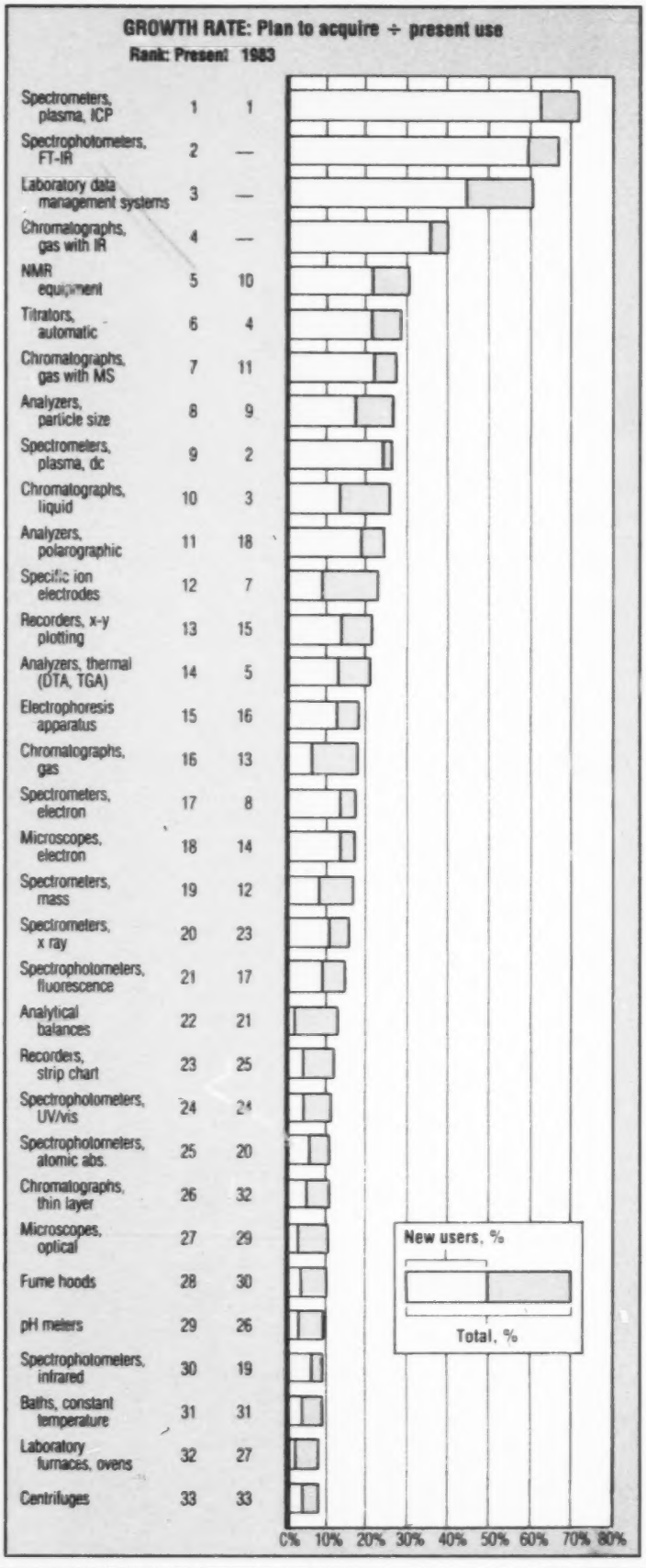
This year, the 13.5% average present use of the three new categories decreases the total average for all 33 categories in this year's Trendsurvey, while their average plans to acquire of just under 8% raises the total average. Eliminating the new categories and using the 30 that are the same as in 1983, one finds an average present use of 33.47% and average plans to acquire of 4.66%. Now, plans to acquire drop instead of rising for 1984.

But that still does not account for changes in demographics for this year's respondents compared to last year's. Engineering claimed 15% more, 23.3% compared to 20.2% last year. Life science and medicine also rose, from 19.0% to 20.2%, while representation of physical science dropped from 58.6% to 53.6%. By employer, industry and government representation dropped slightly while all other sectors rose. And by job function, representation of mangement categories rose while that of professional staff and other unspecified categories dropped.

A normalization procedure was applied to account for all of these demographic changes. For the 30 unchanged categories, this normalization gave an average present use of 33.86%—just 0.53 points, or 1.55%, less than last year's comparable figure. Average plans to acquire rose to 4.75%—0.10 points, or 2.06%, lower than last year.

It should be pointed out that changes in data for use and plans from year to year can affect the results of normalization. For example, for the 30 categories used here, plans to acquire this year for engineering averaged 4.46% compared to 4.28% last year; those for physical science were 5.00% compared to 5.21%. This tends to minimize the shift to engineering in the normalization procedure used. That plans to acquire in the life science and medical sector also rose, from 4.29 to 4.75%, also affects the normalization results. But the changes in plans to acquire are real, and the results of normalization do provide a valid comparison of the unchanged categories.

To add another perspective, of the 30 categories that are the same, 21 show de-


GROWTH RATE: Plan to acquire ÷ present use
Rank: Present 1983
Spectrometers, plasma, ICP 1 1
Spectrophotometers, FT-IR 2 —
Laboratory data management systems 3 —
Chromatographs, gas with IR 4 —
NMR equipment 5 10
Titrators, automatic 6 4
Chromatographs, gas with MS 7 11
Analyzers, particle size 8 9
Spectrometers, plasma, dc 9 2
Chromatographs, liquid 10 3
Analyzers, polarographic 11 18
Specific ion electrodes 12 7
Recorders, x-y plotting 13 15
Analyzers, thermal (DTA, TGA) 14 5
Electrophoresis apparatus 15 16
Chromatographs, gas 16 13
Spectrometers, electron 17 8
Microscopes, electron 18 14
Spectrometers, mass 19 12
Spectrometers, x ray 20 23
Spectrophotometers, fluorescence 21 17
Analytical balances 22 21
Recorders, strip chart 23 25
Spectrophotometers, UV/vis 24 24
Spectrophotometers, atomic abs. 25 20
Chromatographs, thin layer 26 32
Microscopes, optical 27 29
Fume hoods 28 30
pH meters 29 26
Spectrophotometers, infrared 30 19
Baths, constant temperature 31 31
Laboratory furnaces, ovens 32 27
Centrifuges 33 33
New users, %
Total, %
0% 10% 20% 30% 40% 50% 60% 70% 80%

creased present use, 9 increased. Plans to acquire are down in 15 categories, equal in 2, and up in 13, without demographic adjustments. Biggest losers in present use are UV/vis spectrophotometers, infrared spectrophotometers (but with the new FT-IR category, the total for IR is higher), atomic absorption spectrophotometers, GC, polarographic analyzers, and LC. In plans to acquire, LC is the biggest loser, followed by laboratory furnaces and ovens, IR spectrophotometers, automatic titrators, and GC.

Largest gain in present use is in optical microscopes, followed by electron microscopes, mass spectrometers, particle-size analyzers, and electron spectrometers. In plans to acquire, the largest gain is in x-y plotting recorders, followed by strip-chart recorders, particle-size analyzers, GC-MS, constant temperature baths, and optical microscopes.

Ranking by present use is shown in the first bar chart for all 33 categories and "other." On the same total-sample basis, rankings for plans to acquire are lead by the new category, laboratory data management systems, followed by analytical balances, strip-chart recorders, LC, GC, and fume hoods. Rankings by growth rate (plans divided by present use for each category) are shown in the second bar chart. Once again, ICP spectrometers lead the list, followed by the three new categories. The missing 6th ranking from 1983 is automated wet chemical analyzers.

Geographic distribution of respondents again parallels R&D circulation, lending validity to the results, with 6.1% New England, 17.4% Middle Atlantic, 17.9% East North Central, 5.7% West North Central, 13.5% South Atlantic, 2.8% East South Central, 7.1% West South Central, 4.4% Mountain, and 13.3% Pacific. No answer was provided by 11.8% of respondents.

By employer, 57.7% work in industry, 16.0% in universities, 15.5% in government, 3.8% in nonprofit organizations, 2.3% in medical research centers, 3.3% other, and 1.3% gave no answer. Corresponding data for 1983 were 60.3%, 14.7%, 15.8%, 3.1%, 2.0%, 3.0% and 1.1%.

By job function, 4.2% are corporate officers, 7.7% R&D executives, 15.8% project managers, 66.5% professional staff, 4.3% other, and 1.6% no answer. For 1983, the numbers were 3.4%, 6.7%, 13.7%, 69.0%, 5.5%, and 1.7%.

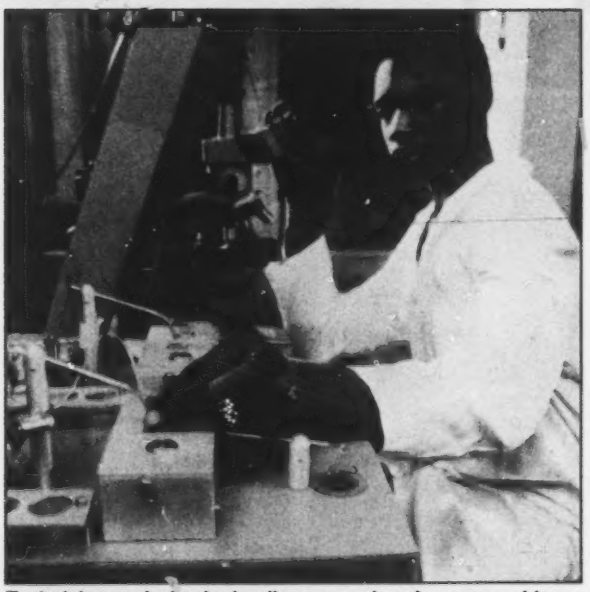
This Trendsurvey was conducted by including a prepaid business reply card in a mailing to R&D readers in the United States in late September 1983. To meet deadlines, only replies received by early November could be included. **R&D**

Growth rate (bar chart at left) is calculated with present use as base for each instrument category. Total includes all those who plan to acquire; new users are those who do not presently use that particular instrument but who plan to acquire. Difference is present users planning to acquire additional or replacement items.

PRESENT AND PLANNED USE: Data from 1,730 respondents * = 1983	Use now								Plan to acquire within 1 year								Growth rate = plan to acquire + by present use				
	Total 1,730		Engineering 403		Physical science 926		Life science or medicine 350		Total 1,730		Engineering 403		Physical science 926		Life science or medicine 350		Total	Present users who plan to acquire		New users	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	%	No.	%	No.	%
Analytical balances	1,530	88.4 *89.5	300	74.4	860	92.7	325	92.9	184	10.6 *11.1	32	7.9	107	11.5	39	11.1	12.0	162	10.6	22	1.4
Analyzers, particle size	309	17.9 *16.8	81	20.1	181	19.5	32	9.1	83	4.8 * 4.0	23	5.7	51	5.5	6	1.7	26.9	29	9.4	54	17.5
Analyzers, polarographic	103	6.0 * 9.0	15	3.7	70	7.5	17	4.9	25	1.4 * 1.3	5	1.2	16	1.7	4	1.1	24.3	5	4.9	20	19.4
Analyzers, thermal (DTA, TGA)	275	15.9 *15.6	66	16.4	182	19.6	16	4.6	57	3.3 * 3.9	11	2.7	39	4.2	6	1.7	20.7	21	7.6	36	13.1
Baths, constant temperature	1,064	61.5 *61.4	183	45.4	568	61.2	284	81.1	101	5.8 * 5.2	20	5.0	53	5.7	27	7.7	9.5	60	5.6	41	3.9
Centrifuges	953	55.1 *57.3	106	26.3	521	56.1	303	86.6	76	4.4 * 4.4	13	3.2	32	3.4	30	8.6	8.0	46	4.8	30	3.1
Chromatographs, gas	760	43.9 *47.1	100	24.8	499	53.8	135	38.6	142	8.2 * 9.4	20	5.0	104	11.2	13	3.7	18.7	95	12.5	47	6.2
Chromatographs, gas with IR	85	4.9 —	24	6.0	49	5.3	9	2.6	34	2.0 —	6	1.5	22	2.4	6	1.7	40.0	3	3.5	31	36.5
Chromatographs, gas with MS	204	11.8 *11.1	18	4.5	147	15.8	33	9.4	56	3.2 * 2.5	8	2.0	37	4.0	11	3.1	27.5	12	5.9	44	21.6
Chromatographs, liquid	547	31.6 *34.2	39	9.7	341	36.7	156	44.6	144	8.3 *10.5	10	2.5	92	9.9	40	11.4	26.3	72	13.2	72	13.2
Chromatographs, thin layer	341	19.7 *21.3	15	3.7	191	20.6	128	36.6	36	2.1 * 1.8	3	0.7	14	1.5	18	5.1	10.6	19	5.6	17	5.0
Electrophoresis apparatus	217	12.5 *12.2	11	2.7	56	6.0	148	42.3	41	2.4 * 2.1	5	1.2	11	1.2	25	7.1	18.9	13	6.0	28	12.9
Fume hoods	1,387	80.2 *81.5	277	68.7	787	84.8	281	80.3	141	8.2 * 7.7	45	11.2	66	7.1	26	7.4	10.2	100	7.2	41	3.0
Laboratory data mngmt. systems	492	28.4 —	112	27.8	261	28.1	111	31.7	299	17.3 —	63	15.6	163	17.6	67	19.1	60.8	82	16.7	217	44.1
Laboratory furnaces, ovens	1,319	76.2 *78.0	301	74.7	747	80.5	232	66.3	105	6.1 * 8.1	38	9.4	57	6.1	8	2.3	8.0	89	6.7	16	1.2
Microscopes, electron	340	19.7 *17.4	94	23.3	177	19.1	58	16.6	62	3.6 * 3.1	31	7.7	24	2.6	7	2.0	18.2	17	5.0	45	13.2
Microscopes, optical	1,177	68.0 *64.1	287	71.2	602	64.9	256	73.1	121	7.0 * 6.4	42	10.4	45	4.8	30	8.6	10.3	92	7.8	29	2.5
Nuclear magnetic resonance equipment	165	9.5 *11.8	11	2.7	122	13.1	28	8.0	51	2.9 * 2.8	9	2.2	31	3.3	9	2.6	30.9	16	9.7	35	21.2
pH meters	1,236	71.4 *72.7	206	51.1	683	73.6	311	88.9	121	7.0 * 7.7	28	6.9	57	6.1	33	9.4	9.8	94	7.6	27	2.2
Recorders, strip chart	1,254	72.5 *73.3	292	72.5	694	74.8	237	67.7	148	8.6 * 7.7	51	12.7	73	7.9	20	5.7	11.8	102	8.1	46	3.7
Recorders, x-y plotting	653	37.7 *38.5	194	48.1	355	38.3	86	24.6	137	7.9 * 6.7	49	12.2	60	6.5	28	8.0	21.0	50	7.7	87	13.3
Specific ion electrodes	553	32.0 *33.1	84	20.8	358	38.6	99	28.3	126	7.3 * 7.8	24	6.0	78	8.4	23	6.6	22.8	75	13.6	51	9.2
Spectrometers, electron	76	4.4 * 3.4	24	6.0	45	4.8	6	1.7	14	0.8 * 0.8	6	1.5	6	0.6	2	0.6	18.4	4	5.3	10	13.2
Spectrometers, mass	271	15.7 *14.4	51	12.7	176	19.0	37	10.6	45	2.6 * 3.2	11	2.7	27	2.9	6	1.7	16.6	22	8.1	23	8.5
Spectrometers, plasma, dc	41	2.4 * 2.6	5	1.2	31	3.3	2	0.6	11	0.6 * 0.9	3	0.7	7	0.8	1	0.3	26.8	1	2.4	10	24.4
Spectrometers, plasma, ICP	64	3.7 * 4.3	6	1.5	51	5.5	5	1.4	46	2.7 * 3.1	4	1.0	40	4.3	2	0.6	71.9	6	9.4	40	62.5
Spectrometers, x ray	235	13.6 *14.1	51	12.7	167	18.0	12	3.4	37	2.1 * 1.7	7	1.7	27	2.9	1	0.3	15.7	13	5.5	24	10.2
Spectrophotometers, atomic abs.	437	25.3 *29.1	35	8.7	319	34.4	70	20.0	47	2.7 * 3.7	5	1.2	30	3.2	12	3.4	10.8	21	4.8	26	5.9
Spectrophotometers, fluorescence	233	13.5 *15.0	22	5.5	115	12.4	91	26.0	34	2.0 * 2.2	2	0.5	13	1.4	17	4.9	14.6	12	5.2	22	9.4
Spectrophotometers, FT-IR	122	7.1 —	19	4.7	83	8.9	14	4.0	82	4.7 —	14	3.5	51	5.5	15	4.3	67.2	10	8.2	72	59.0
Spectrophotometers, infrared	545	31.5 *35.6	65	16.1	393	42.3	70	20.0	53	3.1 * 4.7	6	1.5	37	4.0	9	2.6	9.7	18	3.3	35	6.4
Spectrophotometers, UV/vis	770	44.5 *48.9	69	17.1	470	50.6	214	61.1	85	4.9 * 6.0	12	3.0	39	4.2	32	9.1	11.0	54	7.0	31	4.0
Titrators, automatic	312	18.0 *18.2	37	9.2	211	22.7	55	15.7	91	5.3 * 4.7	16	4.0	60	6.5	12	3.4	29.2	25	8.0	66	21.2
Other	141	8.2 * 9.9	39	9.7	65	7.0	33	9.4	66	3.8 * 4.2	14	3.5	36	3.9	15	4.3	46.8	31	22.0	35	24.8

Survey shows high R&D involvement in quality assurance

At least 70% of scientists and engineers spend 10% or more of their work time doing analysis and testing of components and materials or of final products.



Technician analyzing hydraulic pump valves for wear problems produces ferrogram, then uses ferroscope, above, and colored filters to identify large wear particles shown on facing page.

IF YOU SPEND at least 10% of your work time on quality assurance (including quality control), then you are typical of the respondents to our recent survey of *R&D* readers on this subject.

To the extent that our 900-plus respondents are typical of the research and development industry, it can be said that seven out of ten scientists and engineers in R&D spend at least 10% of their time on QC or QA. Another one in ten does some QA work, but less than 10% of the time.

At the other extreme, more than one out of ten (actually one out of seven) works "nearly full time" on QA or QC.

The involvement of research and development people in quality considerations is not as surprising as it might seem at first. To begin with, in many small organizations the people in the R&D lab are the only ones on the staff who have the expertise necessary for quality analysis.

And, the instrumentation and procedures that they use in quality assurance, say 77% of our respondents who are involved in QA, are much the same as the instrumentation and procedures that they use in their research and development work.

As might be expected, there are notable differences from one discipline to the next. For example, more than 91% of the analytical chemists who responded are involved to some extent in quality assurance, while physical chemists have the lowest involvement at some 62%.

Only 5.6% of the biochemists involved in QA use

procedures that differ more than a little from those used in their R&D work. For ceramists and inorganic chemists, the figure is 30%.

And even though many of our respondents were not directly involved in quality assurance, they reported that some other person or persons in their R&D labs have such responsibilities, emphasizing again the R&D role in quality assurance.

Obviously, a person working alone cannot have a colleague in the same lab who does QA work, and just over 4% of our respondents reported working alone. None of the ceramists, physicists, or biologists reported working alone, but 7.0% of the chemical engineers and 13.0% of the biochemists say they work alone in their labs.

Instrumental chemical analysis is the single category of QC procedure most often used, but nearly half of the labs represented in our study use a combination of chemical and mechanical testing procedures.

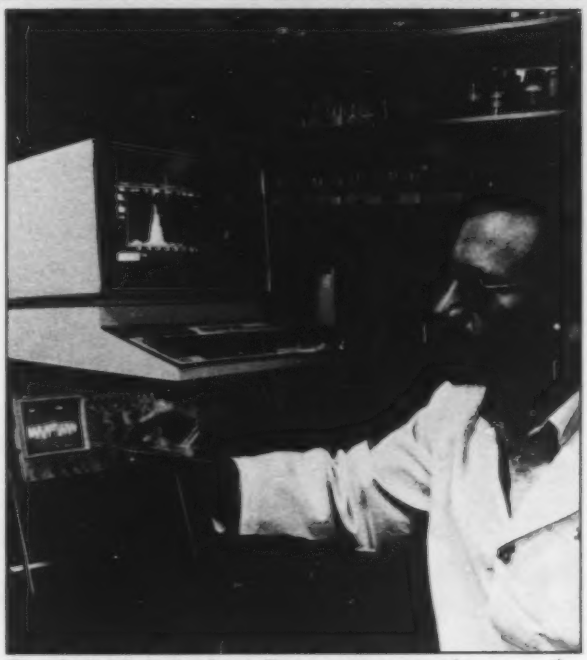
Again, predictably, the procedures of choice vary by discipline. Mechanical testing methods were used a majority of the time by 48.3% of the mechanical engineers, while electrical and electronic test methods were the choice of 68.1% of the electrical engineers.

For all but metallurgists, their own lab procedure dominated. Metallurgists in this survey use ASTM procedures 4:3 over the next highest category.

Results for all respondents follow.

1. *Do you perform quality control or quality assurance work . . .*
   - a. as part of your job assignment or job description? 49.7%
   - b. unofficially or just because it needs to be done? 32.0
   - c. not at all? 18.3
2. *If you answered a or b above, do you do it . . .*
   - a. nearly full time? 14.2%
   - b. 75% of the time? 6.5
   - c. 50% of the time? 11.3
   - d. 25% of the time? 22.7
   - e. 10% of the time? 32.9
   - f. only rarely? 12.4
3. *Do others in your lab do quality control or quality assurance work . . .*
   - a. as part of their job assignment or job description? 62.7%
   - b. unofficially or just because it needs to be done? 23.4
   - c. not at all? 9.7
   - d. I work alone 4.2
4. *Are the QC procedures in your lab primarily . . . (Note that these identify* primary *procedures.)*
   - a. chemical, wet? 6.8%
   - b. chemical, instrumental? 14.3
   - c. mechanical? 9.6
   - d. electrical/electronic? 9.7
   - e. optical? 2.0
   - f. both chemical and physical? 43.8
   - g. comparison to arbitrary standards (visual)? 5.9
   - h. other? 7.9
5. *Is the QC done in your lab related to . . .*
   - a. parts or components? 12.6%
   - b. chemical ingredients? 10.3
   - c. finished products? 21.9
   - d. other? 7.9
   - e. more than one of the above? 48.3
6. *Do your QC procedures and instrumentation differ from those used in your other laboratory activities?*
   - a. yes 23.0% b. only a little 36.2% c. no 40.8%
7. *What test procedures do you use most often?*
   - a. own lab procedures 53.0%
   - b. industry standards 16.3
   - c. ASTM standards 18.7
   - d. NBS procedures 1.4
   - e. military tests 4.0
   - f. others 6.6%

Vibration isolation system permits mechanical engineer to make precise coordinate measurements in product quality role.



Electrical and electronic quality assurance procedures were the choice of 68% of the electrical engineers who were surveyed.

R&D

NOTE

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Research & Development

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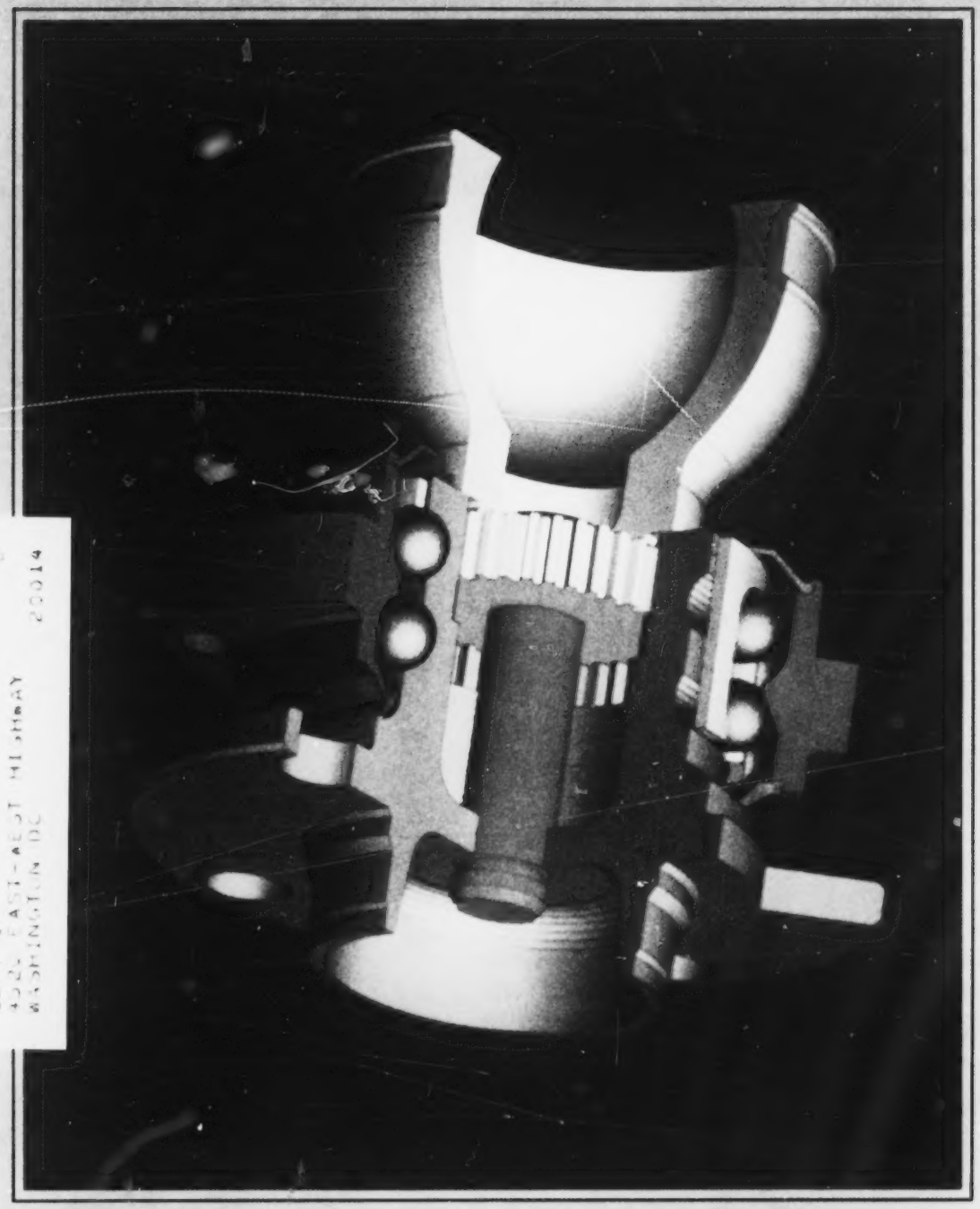
MARCH 1984



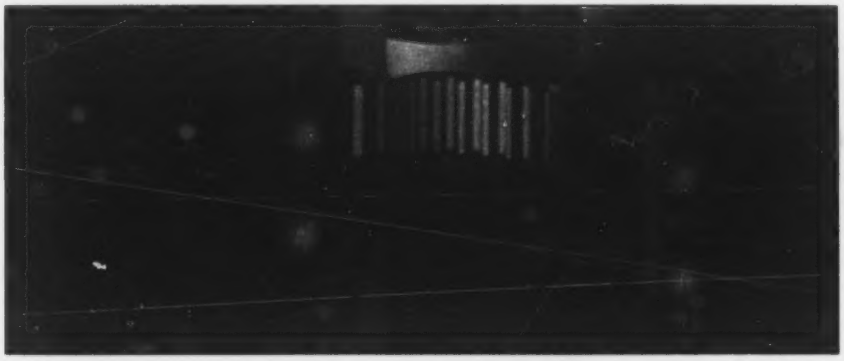
National Design Engineering Show and ASME Conference issue

News of importance to people who work in research, development

Research & Development

SERVING THE $186-BILLION WORLDWIDE R&D INDUSTRY

1984 Design Engineering Show, Chicago, March 26 through 29. See below.



EDITORIAL

11 Space shuttle, nuclear power; double whammy!

DEPARTMENTS

17 Innovative notebook
33 Product development
39 A lawyer's view
45 Research trendletter
49 R/D news in brief
153 Vacuum technology
166 Bookshelf
169 New products
186 R&D product center
191 Literature
209 Opinion poll questionnaire
211 Letters
211 Advertisers index
213 Reader service card

ABOUT THE COVER

The promotion says that "the design engineers who spend more on components, materials, and CAD/CAM systems come to the only show that meets *all* their needs."

The 1984 National Design Engineering Show and ASME Conference at McCormick Place in Chicago, March 26 through 29, is expected to attract 30,000 design engineers and product specifiers.

Among the CAD/CAM uses is a three-dimensional solid modeling system from Magi, Elmsford, NY. The cover art, from Magi, was made on IBM hardware.

NEWS

55 R&D funding: Steady increases for U.S. science in FY85; Sweden to store nuclear wastes under sea

57 Space: NASA, Defense shuttle uses are put under scrutiny; mammoth offshore platform is being studied

58 Electronics: Advanced fault tolerance boosts computer reliability; VLSI technology opens door for self-testing chips

68 Computer security: Concern over computer security turns attention to system administration

71 Aviation: Aerodynamic engineers look beyond supersonic transports; grooves tame air turbulence to improve airplane efficiency

78 Astronomy: U.S. scientists contribute to ESA's Giotto project; ambitious experiments heighten peril of Giotto journey; cosmic ray detector blends many technologies

84 Telescopes: Australian telescope combines high power with low cost

86 Energy & power: Furnace gains efficiency by reusing waste heat

88 Processes: Surface passivation technique could lead to more-sensitive IR detectors; machine accelerates road wear testing

92 New developments: Recent advances brighten outlook for EL displays

ARTICLES

97 Salaries for workers in R&D hold up for most, but just barely: Robert R. Jones, editor, *R&D*; workers earn $19 billion/year.

104 Superconducting metals and alloys help further the 'science of the impossible': Alfred D. McInturff, Fermilab; practical production.

114 Plastics scientists use anatomy of impact to predict behavior: B. Fellman and J. Martin, Instron; brittle or ductile failure?

122 Ceramic-coated metals can survive contact with hot working fluid: S.R. Levine and R.A. Miller, NASA Lewis; thermal barrier coatings.

128 In that vast array of features and options lies a scope for you: Richard Schuessler, Tektronix; you should test the instrument yourself.

135 Ion chromatography uses only one column to get all the ions: T. Jupille, D. Burge, and D. Togami, Wescan; weak ions in complex mixtures.

142 Top management gets into planning strategy for new R&D facility: M.D. Raab, Haines Lundberg Waehler, and G.L. Sutherland, American Cyanamid.

148 Use basic physics and chemistry to help dielectric behavior: H.L. Thomas, associate editor, *R&D*; books don't give all the answers.

153 SARISA — for those difficult to detect sputtered atoms: D.M. Gruen, *et al.*, Argonne; high-sensitivity resonance ionization of atoms.

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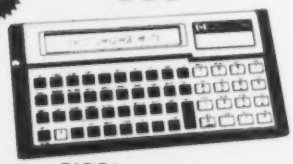

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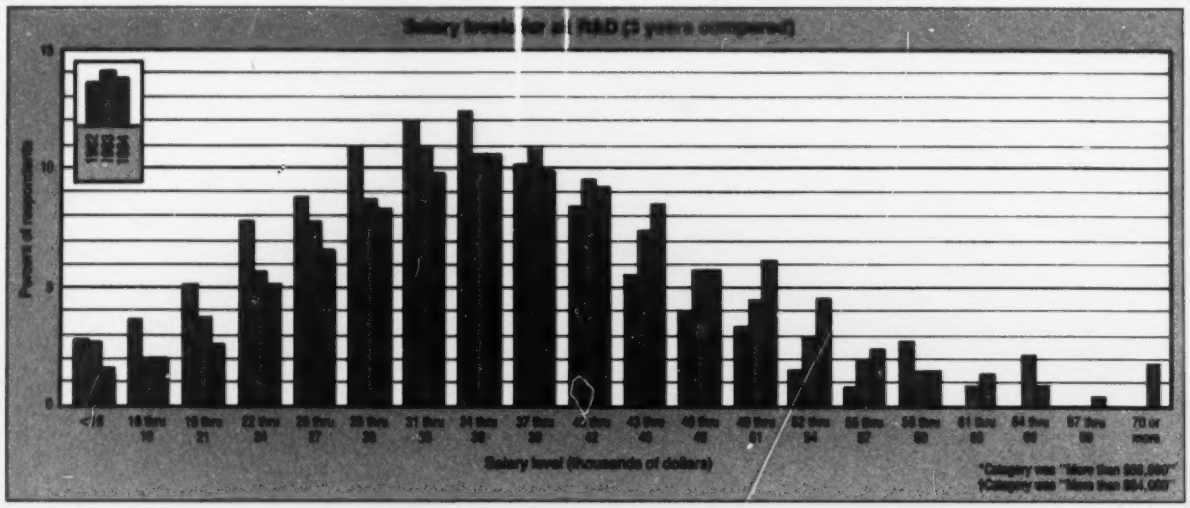


Salaries for workers in R&D hold up for most, but just barely

Net gains were slight in most disciplines, but workers in applied science and technology did not lose ground; and they earn nearly $19 billion a year.

Robert R. Jones
Editor

THERE IS A sameness about certain parts of this year's salary survey results garnered from more than 4,200 respondents who work in research, development, and quality assurance —a sameness when it is compared to last year's—that is at once both wearying and reassuring.

In 1983, our report began with these words: "Salaries are up this year for workers in R&D and quality assurance, as they have been for a number of recent years, but the increases are smaller than in recent years, and some of the gains did not keep up with inflation."

The same is true this year, and the weary drag for our respondents up out of the recession is painfully obvious. However, it is reassuring that the average respondent did not lose buying power in terms of the U.S. inflation rate.

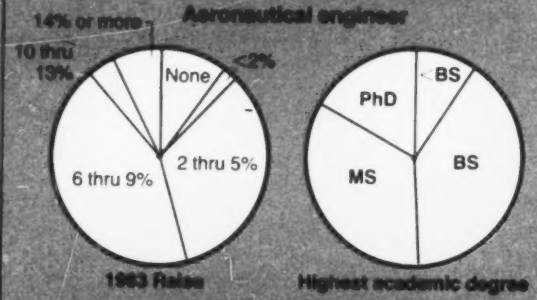
And it is true this year, as it was in the past two years, that the entire salary framework has shifted upward. This increase is demonstrated by our chart which shows "Salary levels for all R&D, three years compared." As there has been in each of the past several years, there is a new upper end for this survey. For this year's report, it is "$70,000 per year or more," and it is occupied by 2.2% of our respondents.

This year, for the first in many years, the percentage of respondents in the lowest salary category, "less than $16,000," has dropped off noticeably. From 2.7% last year it has dropped to 1.6% this year, suggesting that the expansion of the range may be slowing and the upward shift may be more clearly defined.

There is no doubt that salaries for our readers are rising. Just four years ago, 4% of the respondents to this survey said that their annual salary was $46,000 a year or more. The most-populous single salary range that year was $25,000 through $27,000.

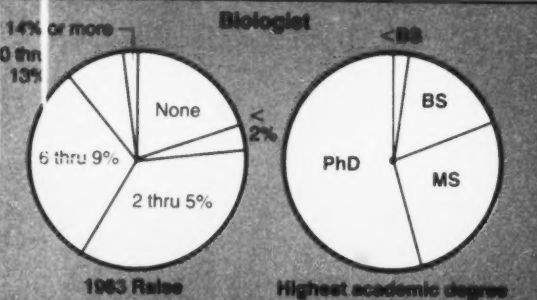
This year's report shows that 25.1% of the respondents are earning $46,000 per year or more. It was 19.6% last year and

Aeronautical engineer



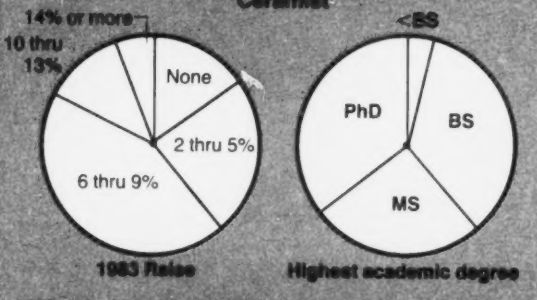
1983 salary range:	<$16,000 = 2.0% >$70,000 = 0.0	Median $43,550
Years with present employer:	< 1 yr = 2.0% >36 yr = 0.0	Median 13.0 yr
Age of respondents:	<26 yr = 2.0% >65 yr = 0.0	Median 48.5 yr
Years of experience:	< 1 yr = 0.0% >40 yr = 2.0	Median 25.9 yr

Biologist



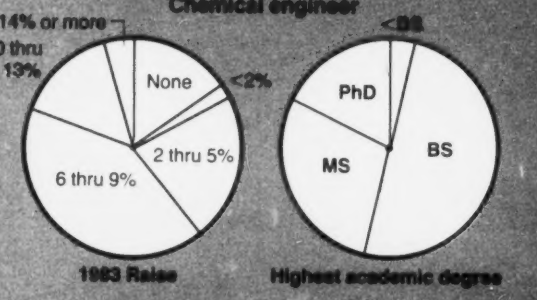
1983 salary range:	<$16,000 = 2.2% >$70,000 = 0.9	Median $33,660
Years with present employer:	< 1 yr = 4.4% >36 yr = 0.4	Median 9.8 yr
Age of respondents:	<26 yr = 2.2% >65 yr = [illegible]	Median 40.1 yr
Years of experience:	< 1 yr = 0.4% >40 yr = 0.9	Median 13.5 yr

Ceramist



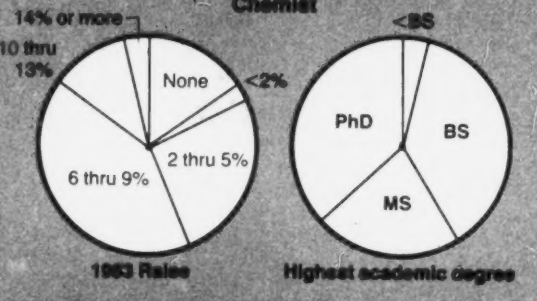
1983 salary range:	<$16,000 = 1.5% >$70,000 = 0.0	Median $39,200
Years with present employer:	< 1 yr = 10.4% >36 yr = 0.0	Median 6.2 yr
Age of respondents:	<26 yr = 7.5% >65 yr = 0.0	Median 37.2 yr
Years of experience:	< 1 yr = 0.0% >40 yr = 1.5	Median 11.0 yr

Chemical engineer



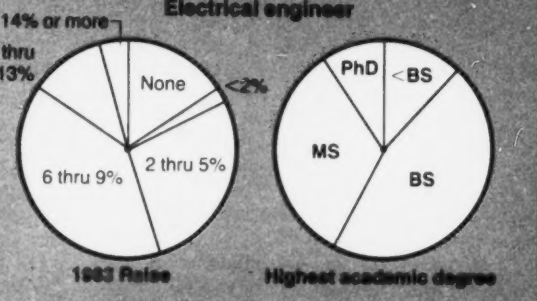
1983 salary range:	<$16,000 = 2.1% >$70,000 = 3.2	Median $40,140
Years with present employer:	< 1 yr = 2.5% >36 yr = 1.4	Median 9.5 yr
Age of respondents:	<26 yr = 5.4% >65 yr = 1.1	Median 40.5 yr
Years of experience:	< 1 yr = 0.7% >40 yr = 2.2	Median 16.7 yr

Chemist



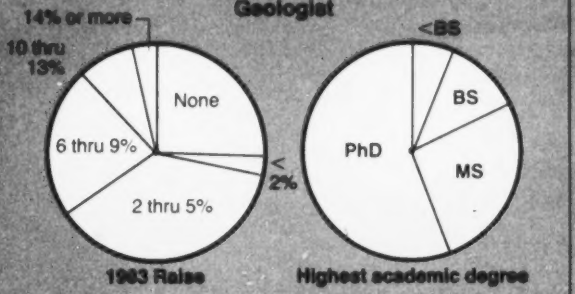
1983 salary range:	<$16,000 = 1.0% >$70,000 = 1.5	Median $36,510
Years with present employer:	< 1 yr = 3.9% >36 yr = 0.8	Median 9.2 yr
Age of respondents:	<26 yr = 2.1% >65 yr = 0.6	Median 40.3 yr
Years of experience:	< 1 yr = 0.3% >40 yr = 1.2	Median 14.1 yr

Electrical engineer



1983 salary range:	<$16,000 = 1.6% >$70,000 = 2.8	Median $39,240
Years with present employer:	< 1 yr = 5.3% >36 yr = 1.6	Median 11.8 yr
Age of respondents:	<26 yr = 3.9% >65 yr = 1.1	Median 45.9 yr
Years of experience:	< 1 yr = 1.4% >40 yr = 2.5	Median 21.4 yr

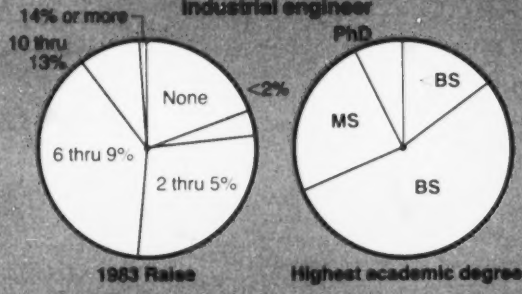
Geologist



1983 Raise — Highest academic degree

1983 salary range:	<$16,000 = 4.0% >$70,000 = 0.0	Median $40,950
Years with present employer:	< 1 yr = 0.0% >36 yr = 0.0	Median 9.0 yr
Age of respondents:	<26 yr = 0.0% >65 yr = 2.0	Median 47.5 yr
Years of experience:	< 1 yr = 0.0% >40 yr = 2.0	Median 18.0 yr

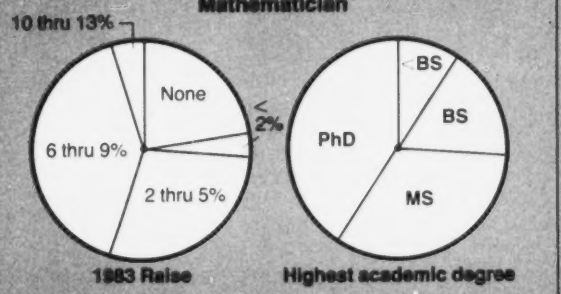
Industrial engineer



1983 Raise — Highest academic degree

1983 salary range:	<$16,000 = 1.8% >$70,000 = 1.8	Median $36,280
Years with present employer:	< 1 yr = 5.4% >36 yr = 3.6	Median 9.6 yr
Age of respondents:	<26 yr = 1.8% >65 yr = 7.0	Median 42.4 yr
Years of experience:	< 1 yr = 0.0% >40 yr = 5.3	Median 16.5 yr

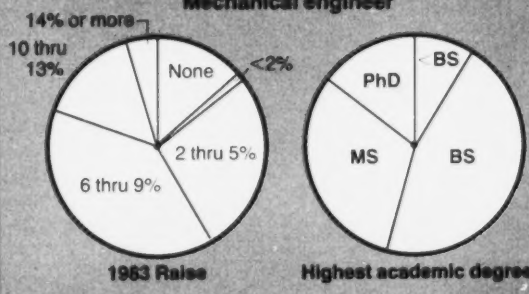
Mathematician



1983 Raise — Highest academic degree

1983 salary range:	<$16,000 = 0.0% >$70,000 = 7.4	Median $44,750
Years with present employer:	< 1 yr = 0.0% >36 yr = 0.0	Median 17.8 yr
Age of respondents:	<26 yr = 0.0% >65 yr = 0.0	Median 50.5 yr
Years of experience:	< 1 yr = 0.0% >40 yr = 3.7	Median 23.6 yr

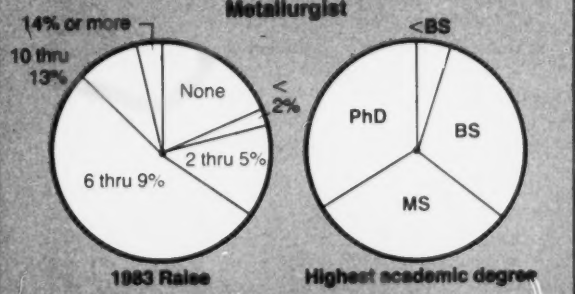
Mechanical engineer



1983 Raise — Highest academic degree

1983 salary range:	<$16,000 = 0.2% >$70,000 = 2.5	Median $40,010
Years with present employer:	< 1 yr = 3.0% >36 yr = 0.5	Median 10.5 yr
Age of respondents:	<26 yr = 2.5% >65 yr = 1.5	Median 44.1 yr
Years of experience:	< 1 yr = 0.0% >40 yr = 4.2	Median 19.6 yr

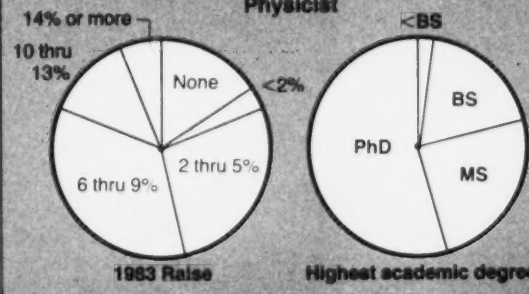
Metallurgist



1983 Raise — Highest academic degree

1983 salary range:	<$16,000 = 0.9% >$70,000 = 3.6	Median $41,310
Years with present employer:	< 1 yr = 4.1% >36 yr = 0.0	Median 7.8 yr
Age of respondents:	<26 yr = 1.8% >65 yr = 0.5	Median 40.4 yr
Years of experience:	< 1 yr = 0.5% >40 yr = 1.8	Median 14.5 yr

Physicist



1983 Raise — Highest academic degree

1983 salary range:	<$16,000 = 2.2% >$70,000 = 2.5	Median $40,770
Years with present employer:	< 1 yr = 6.1% >36 yr = 1.1	Median 9.4 yr
Age of respondents:	<26 yr = 1.9% >65 yr = 2.2	Median 43.0 yr
Years of experience:	< 1 yr = 1.1% >40 yr = 1.4	Median 16.8 yr

12.5% in 1982. This year's most-populous salary range is $34,000 to $36,999 with 10.8% of our respondents there.

All of this adds up to a significant salary check for the R&D industry, a whopping $18.9 billion per year.

With all of this, the median salary for R&D workers has continued to rise. During this past year the rate of increase was much slower than previously, however. In 1981 the increase was 7.8%. In 1982 it was 7.7%. Last year's gain was only 4.25%.

More important for U.S. readers, perhaps, is the fact that in each of the years the increase was greater than their annual rate of inflation.

Buying power was maintained despite the fact that there was a sharp decline in the number of large salary increases. Only 15.9% of our respondents received salary increases of 10% or more last year, compared to 33.4% who received such increases a year ago. Two years ago it was 47.3%, nearly three times this year's percentage.

The differences in rates of salary increase can be seen in the following table:

Increases in salary, all levels R&D

	% of respondents				
Amount	1984	1983	1982	1981	1980
None	16.3	14.7	6.3	5.2	5.7
Less than 2%	2.1	1.9	1.2	0.9	1.5
2 thru 5%	26.9	15.9	10.6	8.0	12.4
6 thru 9%	38.9	34.2	34.5	45.2	52.0
10 thru 13%	11.5	25.1	34.0	29.7	19.6
14% or more	4.4	8.3	13.3	11.0	8.8
Ahead of inflation	54.8	33.4	47.3	40.7	28.4

There are two important things to note in the table. The first is that the number receiving no increase at all has climbed from 6.3% in 1982's report to 14.7% last year and 16.3% this year. Second, because the rate of U.S. inflation has fallen to the 4% range, nearly 55% of this year's respondents received raises that exceeded the rate of inflation, up substantially from earlier years.

The highest percentage of salary increases of 6% or more went to the chemical engineers, with 60.8% doing that well. They barely nosed out the high-flying ceramists for first place. Ceramists, who placed 90% in that upper-increase range two years ago and 83.3% there last year, had 60.6% with raises of 6% or more for this year's report.

Even then, chemical engineers, this year's leaders in 6%+ raises, were down from having 73.8% do that well last year.

Details of this year's salary increases and those for five other salary parameters are displayed in charts for 12 disciplines on the accompanying pages. These charts present an opportunity for you to make comparisons, by disciplines, of education and of salary for age, experience, and longevity using information that is available nowhere else.

Looking at median salaries by disciplines, mathematicians, with 16.4% median salary gain for the past year, moved up from fourth to first place in the rankings. Geologists and industrial engineers also made strong gains.

Poorest showings were made by ceramists and biologists, both losing rank in the comparison table.

Rankings for disciplines by median salary

Rank			Median salary		
1984	1983	Discipline	1984	1983	% increase
1	4	Mathematician	44,750	38,450	16.4
2	1	Aero. Engr.	43,550	41,150	5.8
3	6	Metallurgist	41,310	38,333	7.8
4	9	Geologist	40,950	36,950	10.8
5	3	Physicist	40,770	38,500	5.9
6	2	Chem. Engr.	40,140	38,890	3.2
7	7	Mech. Engr.	40,010	38,100	5.0
8	8	Elec. Engr.	39,240	37,480	4.7
9	5	Ceramist	39,200	38,400	2.1
10	10	Chemist	36,510	34,880	4.7
11	13	Indust. Engr.	36,280	30,520	15.8
12	11	Biologist	33,660	34,380	− 2.1
13	12	Other	33,480	32,450	3.2

Last year's report, bringing data from the depth of the recent recession, appeared to suggest that limited hiring was putting a premium on age, experience, and advanced degrees. This year, with the recession having eased, there appear to be more opportunities for newcomers to R&D.

This would be one explanation for a decrease in the percentage of respondents with PhD degrees. The percentage has moved from 27.6 in 1980 to 29.4 in 1981, 30.2 in 1982, and 32.3 in 1983. This year it dropped off slightly to 30.8.

Biologists no longer lead the disciplines in the percentage with a PhD, having been crowded out of first place by the geologists at 56.0%. Biologists are second at 54.5, and physicists are close behind at 54.3% PhD.

There is a substantial gap from the biologists to the fourth-place discipline, mathematicians at 40.7% PhD. They are followed by chemists, 36.9%; ceramists, 35.4%; and metallurgists, 33.2%.

Industrial engineers have the lowest percentage of respondents with a PhD degree at 7.1.

When masters and doctorates are considered together and the disciplines are ranked for advanced degrees, geologists lead with 82% having an advanced degree. Biologists are next at 80.6%, followed by physicists, 78.8%; mathematicians, 74.0%; and metallurgists, 65.0%.

In the second part of this report, we will look into the implications of some of the above conclusions and also report on the value of an advanced degree to its holder, the premium that is being paid for experience, and the relative salary scales of men and women who work in research, development, and quality assurance. **R&D**

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APRIL 1984

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News of value to people who work in R&D

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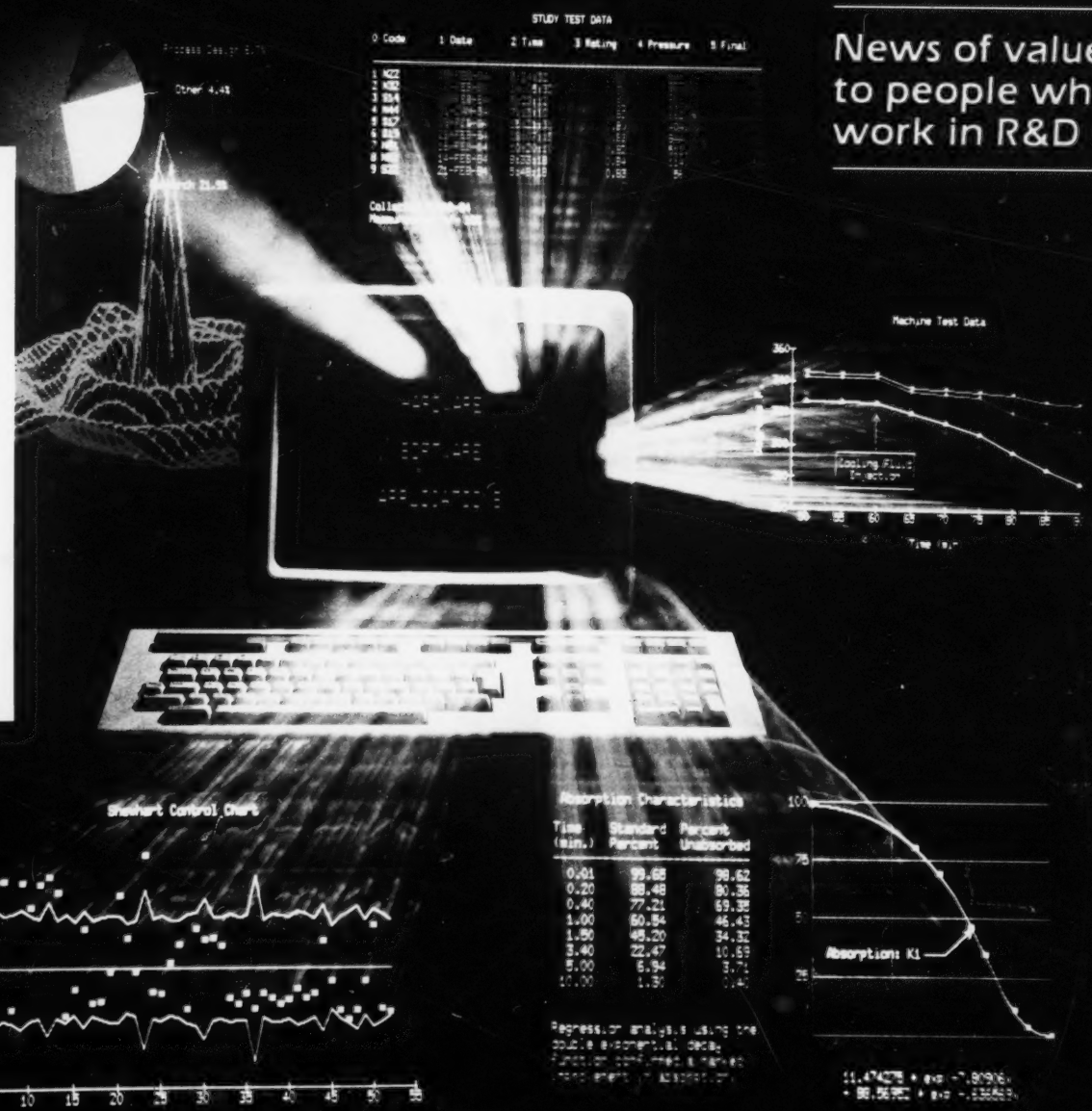

Research & Development

SERVING THE $186-BILLION WORLDWIDE R&D INDUSTRY

Software for R&D labs. See p 94.

EDITORIAL

11 **'Scientific fact' and scientific speculation**

DEPARTMENTS

17 **Innovative notebook**
31 **Product development**
39 **A lawyer's view**
47 **Research trendletter**
51 **R/D news in brief**
143 **Vacuum technology**
151 **New products**
161 **R&D product center**
165 **Literature**
179 **Bookshelf**
182 **Opinion poll questionnaire**
184 **Opinion poll results**
188 **Letters**
195 **Advertisers index**
197 **Reader service card**

ABOUT THE COVER

The advent of computer software designed specifically for the handling of research-generated data has given to scientists and engineers a powerful tool for speeding their work and for avoiding systematic errors.

Graphics packages allow the user to view and to present data in various ways to improve understanding of lab results. Statistics packages aid the user in analysis of the information and in the prediction of results from future experiments.

The cover, from BBN Software Products Corp., Cambridge, MA, was produced for this issue by photographer Steve Grohe.

Related articles begin on pp 94, 102, 108, and 120.

NEWS

59 **Nuclear:** Nuclear power hits new low; European group plans fast reactor; significant changes needed in nuclear industry—OTA; Maiman in Hall of Fame

62 **Optoelectronics:** Japanese firms are poised to dominate optoelectronics

65 **Environment:** UK program will explore Earth's troposphere

66 **Science policy:** Tech export policies and politics sap stength of EAA; mirrors direct high-energy laser beams; ESA awards tribology lab contract

72 **Materials:** Chemical impurities toughen dielectrics to radiation; advance may aid molecular computers; space shuttle uses are seen for fibrous ceramics

76 **Astronomy:** Astronomers take inside track in San Diego lighting battle

78 **Space:** 3M will pursue materials processing in space

80 **Automation:** UCLA program trains for totally automated factories

85 **Conferences:** Labcon West gears up for its second year

87 **Communications:** British plan automobile linkups via satellite

88 **Innovation:** OTA finds that many local factors influence high-tech research initiatives; small firms are seen as pivotal to innovation; data transfer rate is boosted to 5 Gbit/sec

90 **R&D funding:** UK civilian R&D funding continues to decline

ARTICLES

94 **Today's integrated scientific software adapts to the problem:** C.H. Russell, BBN Software Products; save time for R&D.

102 **Computer simulation of magnetic fields aids design process:** J.S. Colonias, Lawrence Berkeley Laboratory; numerical modeling.

108 **Computer program predicts Jominy end quench hardenability:** John Tartaglia, AMAX Materials Research; predictive research.

114 **Moving stage improves accuracy of microcircuit measuring technique:** R.D. Young, R.D. Young Consultants; microscope stage.

120 **Let your software do the 'thinking' for UV/vis spectroscopy:** F.G. Padera, Perkin-Elmer; speed analysis and improve accuracy.

128 **New technique can calibrate your surface temperature sensors:** S.P. Schumann, Owens-Corning; special technique for large plate.

136 **Acoustic microscopy gains resolution, finds new applications:** M. Hoppe and W.J. Patzelt, Ernst Leitz Wetzlar; new tool for QA.

143 **Controller simplifies pressure measurement in vacuum systems:** M. Cox, Edwards High Vacuum; vacuum gage controller.

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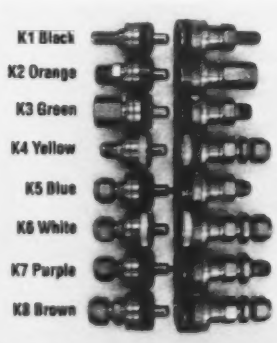

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OPINION POLL RESULTS

R&D workers continue love affair with personal computer

SEVENTY-EIGHT percent of the workers in research, development, and quality assurance have regular access to at least one personal computer, if the more than 2,400 respondents to our recent survey on this subject are typical of the industry.

In asking this question and others that are discussed below, we defined a PC as "having I/O capability, having performance between that of programmable handheld calculators and of the true desktop computers, and costing less than $5,000."

Software is a problem for many of the respondents, and 83% say they write some or all of the software for their work. Data processing is the largest single category of PC application for our readers, and data acquisition is the third largest. Together, they make up 48% of the PC applications.

Second-largest use of PCs by our respondents was for word processing, it being the primary use for one in every eight respondents. While this heavy word-processing activity might be taken as an indication that "publish or perish" continues to be a real threat in many fields, it should be pointed out that word processing provides substantial advantages for report writing, especially when a program combines data- and word-processing activities.

Of the respondents who do not have regular access to a PC (22%), 56% expect to have such access soon. However, this should not be taken to indicate that the remainder will lack regular access to the advantages of computing. Many of those will not get a PC because they have regular access to a desktop, a mini, or a mainframe.

Looking at the responses by disciplines, data processing is the primary application for a PC for 52% of the responding ceramists, 49% of the biologists, and 44% of the aeronautical engineers. Data processing is the primary application for only 20% of the electrical engineers who list CAD/CAE, word processing, and equipment/process control as other important applications for them.

When it comes to peripherals, the combination of disk drive, CRT display, dot-matrix printer, and telephone modem is used by 54% of the ceramists, 49% of the metallurgists, 46% of the physicists, and 45% of the electrical engineers.

Letter-quality printers are used by 31% of the industrial engineers, 25% of the mathematicians, and 27% of the "others."

Complete results of this survey, by discipline, appear on the opposite page.

CIRCLE 260 ON INQUIRY CARD

Percent of respondents by disciplines

	Chemist	Chemical engr.	Mechanical engr.	Electrical engr.	Aeronautical engr.	Industrial engr.	Physicist	Metallurgist	Biologist	Mathematician	Ceramist	Geologist	Other	All respondents
1. Do you have regular access to a personal computer?														
a. Yes, at work	33	37	26	27	19	22	32	37	40	35	31	35	31	32
b. Yes, at home	17	19	23	20	29	16	18	18	8	17	7	27	14	17
c. Yes, both	28	18	25	38	26	36	36	21	33	35	31	15	31	29
d. No	22	26	27	15	26	26	14	24	19	13	31	23	24	22
(If yes, go to No. 3.)														
2. Do you expect to have regular access to one soon?														
a. Yes, at work	24	27	33	23	57	33	26	23	36	33	11	0	27	26
b. Yes, at home	20	18	7	30	0	17	31	14	18	0	11	33	14	18
c. Yes, both	9	8	13	12	14	25	6	9	14	0	22	17	23	12
d. No	47	47	45	35	29	25	37	54	32	67	56	50	37	43
(If yes, go to No. 7. If no, go to No. 9 to list your discipline.)														
3. Do you plan to acquire another one soon?														
a. Yes, same brand and model	8	6	5	4	11	16	8	3	8	11	10	10	8	7
b. Yes, same brand, more powerful	14	19	17	23	16	25	5	16	16	21	15	5	15	17
c. Another brand	21	20	23	24	5	28	27	25	25	26	10	20	25	23
d. No	57	55	55	49	68	31	50	56	51	42	65	65	52	53
4. Do you have a PC that is conveniently portable?														
a. Yes	28	20	34	33	20	48	30	22	27	30	35	50	25	29
b. No	72	80	66	67	80	52	70	78	73	70	65	50	75	71
5. Is available software adequate for your needs?														
a. Yes	58	59	61	63	65	58	61	58	58	55	70	50	61	60
b. No	42	41	39	37	35	42	39	42	42	45	30	50	39	40
6. Do you write your own software?														
a. Yes, all	8	11	12	16	15	15	18	12	8	35	15	5	10	11
b. Yes, some of it	73	75	71	72	80	82	76	70	58	60	75	85	66	72
c. No	19	14	17	12	5	3	6	18	34	5	10	10	24	17
7. Do you use (or plan to use) a PC primarily for . . .														
a. Data processing	39	36	27	20	44	22	28	33	49	43	52	39	33	34
b. Electronic filing	7	4	6	9	0	2	3	5	3	0	0	0	7	6
c. Financial management	5	8	7	6	9	15	5	8	5	0	9	9	4	6
d. Education	9	8	9	9	4	5	11	14	4	10	4	22	9	9
e. Data acquisition	13	8	15	7	0	12	17	19	12	5	17	9	10	12
f. Word processing	14	15	13	17	26	28	19	10	17	10	13	13	19	16
g. CAD/CAE	1	4	12	11	4	2	2	0	1	10	0	4	4	4
h. Equipment/process control	7	8	6	13	0	12	6	8	5	5	0	4	6	7
i. Other	5	9	5	7	13	2	9	3	4	19	4	0	8	6
8. Do you have now or plan to acquire soon . . .														
a. Disk drive	6	4	8	7	8	3	6	9	5	5	4	9	3	6
b. Cassette drive	3	4	6	3	4	0	3	1	4	0	4	9	5	4
c. CRT display	2	3	3	1	4	0	3	3	1	0	8	0	1	2
d. Dot-matrix printer	3	1	2	1	8	0	3	1	2	10	0	4	3	2
e. Letter-quality printer	3	4	1	3	0	5	3	1	3	5	4	4	5	3
f. Telephone modem	3	1	2	6	0	5	3	3	6	15	0	4	6	4
g. a + c + d	33	32	33	30	24	30	37	43	27	20	46	35	27	32
h. a + c + e	11	13	13	9	12	23	8	9	15	20	0	13	17	12
i. g + f	12	11	4	15	4	10	9	6	10	25	8	4	12	11
j. h + f	4	6	2	6	8	3	5	1	8	0	4	4	5	5
k. Other	9	6	9	6	12	3	9	5	7	0	0	0	6	7
l. None	11	15	17	13	16	18	11	18	11	0	21	13	9	12

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The 1984 Laboratory of the Year

Recent advances in industrial biotechnology

Our unique R&D news section

Research & Development

SERVING THE $186-BILLION WORLDWIDE R&D INDUSTRY

Integrated facility reflects R&D activity in High Honors lab. See p 92.

EDITORIAL

11 We could stretch high technology until it breaks

DEPARTMENTS

17 Innovative notebook
25 Product development
31 A lawyer's view
37 Research trendletter
41 R/D news in brief
125 Vacuum technology
142 Bookshelf
145 New products
159 Literature
161 R&D product center
181 Opinion poll results
183 Letters
187 Advertisers index
189 Reader service card

ABOUT THE COVER

We proudly present to you the 1984 *Research & Development* Laboratory of the Year. We congratulate the architects, scientists, and planners responsible for the design of the Warner-Lambert Consumer Products R&D Center in Morris Plains, NJ.

The Lab of the Year judges also cited for High Honors the Chevron Research Laboratory Building E and the Westvaco Forest Science Laboratory.

An article describing these and other well-designed labs begins on p 92.

NEWS

49 Toxic substances: Nerve gas tests anger residents of Cambridge, MA; space antenna deployment demonstrated; panel hits toxicity testing of commercial chemicals; researchers factor 71-digit number

51 Nuclear magnetic resonance: Zero-field technique could expand NMR applications

52 Separation technology: New industries boost outlook for separation technologies

56 Science policy: Reagan expands DOD's authority in tech export; telescope will incorporate many technological advances

60 Electronics: MCC appoints directors of its R&D programs; Japanese try to recruit British software engineers

64 Geophysics: Seismic waves are used to map Earth's interior; European program encourages joint R&D

68 Fluorescence: Fluorescence method is used to optimize chemical lasers

72 Conferences: Expanded program is planned for Labcon Central

74 New developments: Hearing aid is developed for the totally deaf; many advantages are seen for flat antennas

Special Report—Space Development

79 Obstacles fall as Reagan pushes hard for space station; Europe considers its space options; ESA lobbies to lower price of shuttle service; NASA becomes more ambitious in satellite retrieval; plans are set for ocean drilling project

ARTICLES

92 'Borrowed' light reaches inner spaces in Lab of the Year: H.L. Thomas, associate editor; winner is Warner-Lambert Consumer Products R&D Center, Morris Plains, NJ.

102 Recovering a product—the last hurdle in the bioprocessing race: E.S. Lipinsky, B.R. Allen, D.M. Jenkins, L.M. Curran, Battelle; economic feasibility depends on product recovery.

106 DNA synthesizers provide 'catalyst' for genetic research gains: R.M. Cook, Biosearch Inc.; automated gene machines eliminate the tedium in making nucleotides.

112 Industry pulls ahead of government in R&D median salaries: R.R. Jones, editor; career premium for PhD degree tops $600,000; low wages for women in academia.

118 Old and new problems are solved by polymers containing graphite: B.M. Vanderbilt and F.R. Chipps, R.E. Darling Co.; graphite improves properties of thermoset polybutadiene.

125 Optical emission can end your etch process on time, every time: Gene Scott, Xinix Inc.; spectroscopy technique provides reliable endpoint control of semiconductor production.

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Robert R. Jones
Editor

Industry pulls ahead of government in R&D median salaries

Career premium for PhD degree averages more than $600,000, but doctoral women working in universities get far less.

THE VALUE of an advanced degree is obvious in research, development, and quality assurance. As was mentioned in the preceding article (in our March issue), the net value of a PhD over a BS depends on an individual's field of endeavor and sex, and whether the employer is from industry, academia, or government.

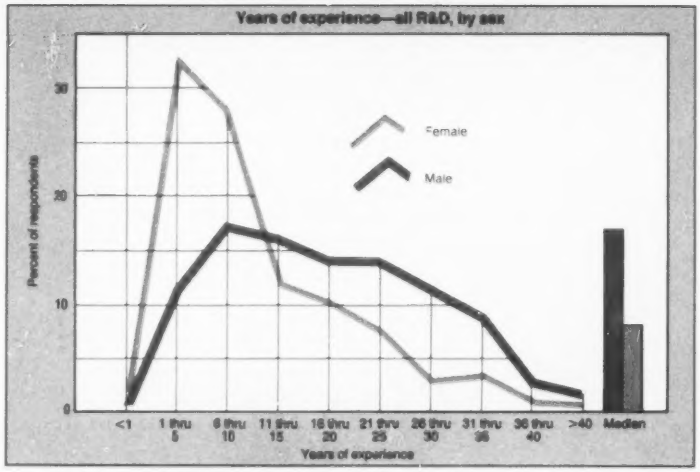
For the average of the PhD-holders among this year's more than 4,200 respondents, the net value of a PhD over a BS in a 25-year career is nearly $620,000. That is what remains after deducting for costs of the added education and allowing for the additional years spent in school.

We assume that the holder of the PhD will work approximately 25 years after getting that degree, as our survey shows is typical. We allow a 30-year career for the person who enters the work force after getting a BS. Assuming a 10% interest rate prevailing over the 25-year career of the PhD and allowing $300,000 for tuition, missed earnings, etc., we then can make appropriate projections.

The value of a PhD over an MS is more than $370,000; and for a PhD over less than a BS it is $875,000.

Getting a BS is a good investment. The net benefit of a BS over less than BS is more than $255,000. Adding the MS is worth an additional $250,000 over a 25-year career.

For our respondents as a whole, median salaries by highest academic degree are compared in this table:

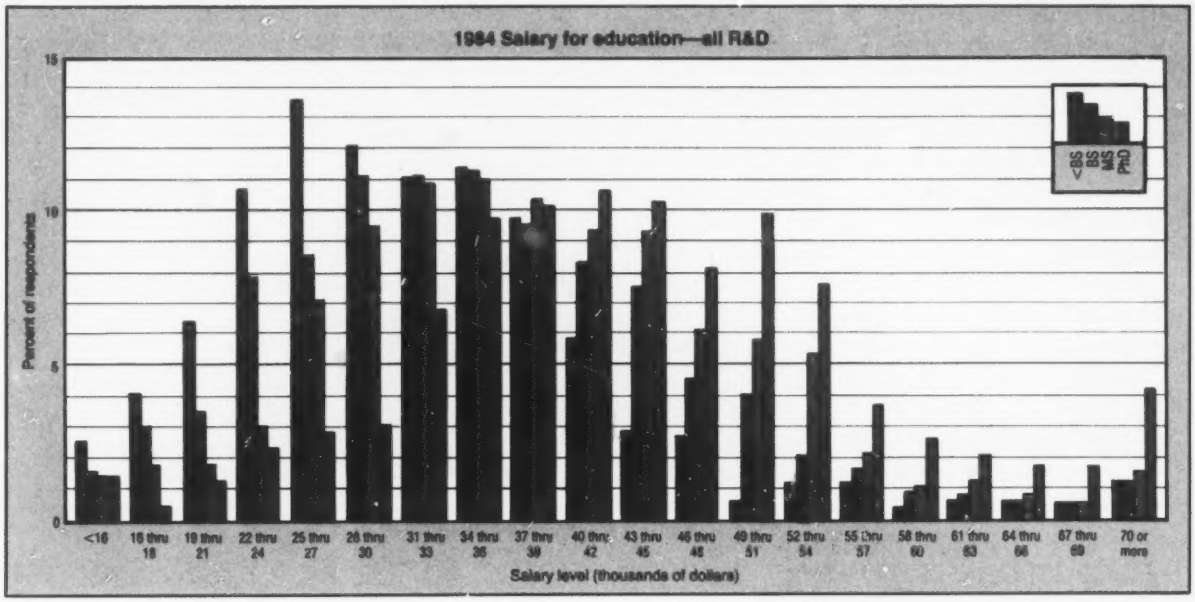


Salaries compared by academic degrees

Degree	Median salary 1984	Median salary 1983	Percent change	Annual difference* 1984	Annual difference* 1983	Difference increase%
Doctorate	$43,200	$40,590	+6.4	$5,280	$4,310	+22.5
Master	37,920	36,200	+4.5	3,210	3,100	+3.5
Bachelor	34,710	33,180	+4.6	3,760	5,100	−26.3
<Bachelor	30,950	27,670	+11.8			

*Difference above next-lower degree

As was true a year ago, the income advantages of baccalaureate and advanced degrees are increasing faster than inflation. The advantage in annual income for a PhD over less than bachelor this year is $12,250, down from $12,920 last year, but still well above the $9,990 spread of three



years ago.

The advantage of a PhD over a BS now is $8,500 per year, compared to $7,400 last year and $7,250 two years ago.

As with any averages, much additional information is needed to make the situation clear. Women who work in research, development, and quality assurance earn a lot less than men do, but that is not to say they always earn less for equal work. For many reasons the female work force cannot be compared directly with the male counterparts.

Because of differences in opportunities, women almost always have less experience than men in R&D and QA. They usually have less time with their present employers. And they usually have less education. Thus, the higher paying jobs tend to be occupied by males with advanced degrees and substantial work experience.

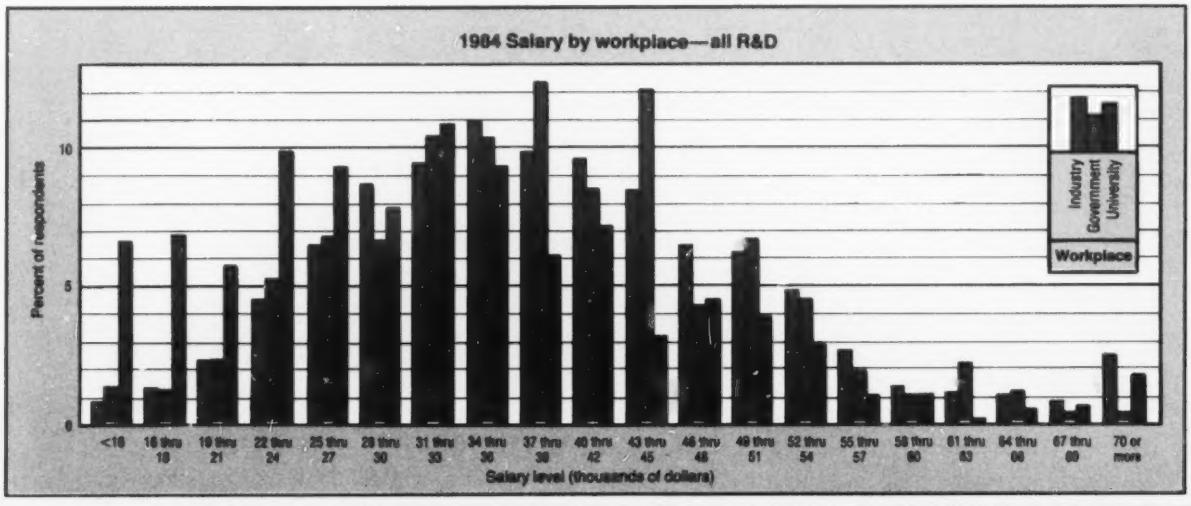
When all of the differences are brought to bear, we find that the male R&D worker in industry is earning a median annual salary of $39,200 in contrast to the female R&D worker in a university where her median annual salary is $20,450.

Looking at salaries for workers in R&D and QA by sex and work place, we find important differences from government to industry to university. One important change here is that government has recently relinquished some of its traditional salary leadership to industry.

Another is the male-female salary difference mentioned above, leading to the fact that the lowest male median still exceeds the highest female median. The ranking is as follows:

Men in industry	$39,200
Men in government	38,630
Men in universities	32,580
Women in industry	29,590
Women in government	29,450
Women in universities	20,450

In this year's survey, the median annual income for all males is $38,440 and for



all females it is $28,990.

That old idea that "Uncle Sugar" pays the best wages is hard to stomp out. Over the years this survey has tended to support that idea. But no more. Compare the differences in 1980 and 1984 medians for all workers by work place:

	1980	1984
Government	$29,733	$38,210
Industry	28,354	38,550
University	25,685	31,890

You might point out, in response to the above, that there are proportionately more women working in the universities, a fact which would pull the university medians down. But don't forget, there are proportionately more PhDs in the universities, and that should help to pull the salaries back up—but, obviously, not back up to the level of industry.

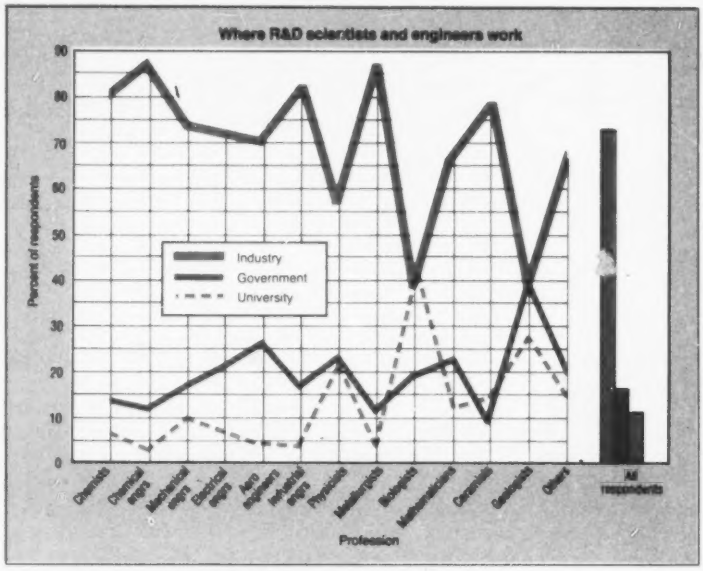
When it comes to salary increases, women did as well (or as poorly) as men at the low end of the scale last year. For both sexes, 18.3% received salary increases of less than 2%. At the upper end, women did substantially better than men, with nearly a third more getting increases of 10% or more.

Salary increases by sex

	1983 %		1982 %	
Amount	Male	Female	Male	Female
None	16.3	15.6	14.8	12.9
Less than 2%	2.0	2.7	1.9	1.1
2 thru 5%	27.3	20.5	15.8	17.7
6 thru 9%	38.9	39.5	34.2	33.4
10 thru 13%	11.2	15.6	25.2	23.1
14% or more	4.3	6.1	8.1	11.8

Some 37.7% of the women respondents are earning $31,000 per year or more, up from 34.9% last year and 25% two years ago. But, as would be expected, men dominate the upper brackets, with 75.7% of the male respondents earning more than $31,000 per year, up from 71.3% last year and 63.0% two years ago.

Our chart shows that women in R&D



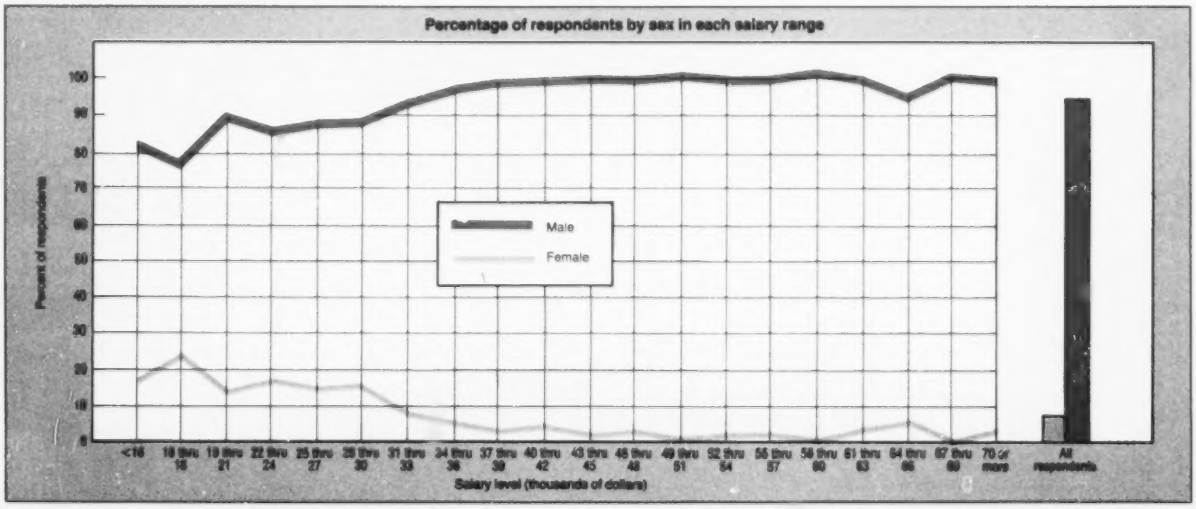
and QA continue to lag far behind men in work experience, certainly to no one's surprise. Median years of experience for males in R&D is 16.73 years, virtually unchanged for the past several years. For women, the median is 7.86 years, little changed from earlier reports.

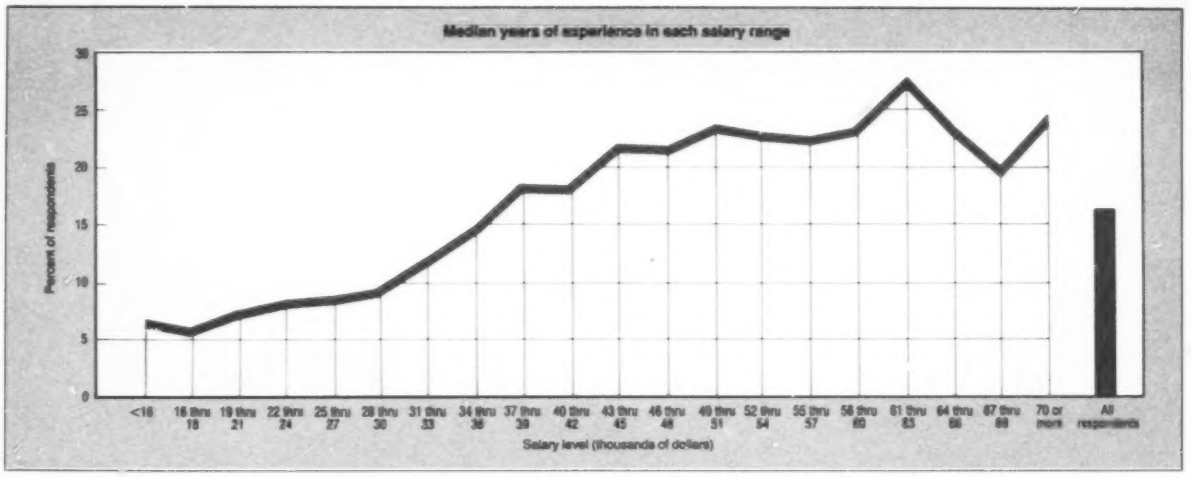
A full 40.0% of the male respondents report having more than 20 years' experience, up slightly from recent years. Less than half that percentage, or 15.5%, of the female respondents report having 20 years' experience in their present work, up from a year ago and in line with earlier reports.

At the low end of experience, 34.2% of the female respondents have less than six years' experience in their present work, compared to 12.2% for the men.

One factor limiting women's work experience is that only recently have significant numbers been moving into the work force. While 74.7% of the women are younger than 40 years of age, only 45.0% of the men are that young.

This is reflected in the fact that many





women have not had an opportunity to earn an advanced degree. The percentage of women in this year's respondents who have a PhD is down from a year ago at 14.8 and in line with earlier years. This year's male respondents are in line with previous years at 31.9% PhD.

Longevity, time with the same company, always is a factor in salary. The fact that 4.2% of the male respondents have been with their present employers for more than 30 years helps to explain their higher position on the salary scale. Only 2.0% of the women have the same longevity.

Women with fewer than seven years in the same firm make up 60.8% of the female respondents, up slightly from recent years. Only 38.7% of the males have been with their present employer for less than seven years.

Much additional information about the people who work in research, development, and quality assurance is provided in the accompanying charts and tables.

Following are complete results of the Opinion Poll Survey:

1984 R&D Salary Survey Results

1. What is your annual salary?

a. Less than $16,000	1.6%
b. $16,000 to $18,999	2.0
c. $19,000 to $21,999	2.6
d. $22,000 to $24,999	5.1
e. $25,000 to $27,999	6.9
f. $28,000 to $30,999	8.3
g. $31,000 to $33,999	9.9
h. $34,000 to $36,999	10.8
i. $37,000 to $39,999	10.0
j. $40,000 to $42,999	9.2
k. $43,000 to $45,999	8.6
m. $46,000 to $48,999	6.0
n. $49,000 to $51,999	6.1
o. $52,000 to $54,999	4.7
p. $55,000 to $57,999	2.4
r. $58,000 to $60,999	1.4
s. $61,000 to $63,999	1.4
t. $64,000 to $66,999	0.9
u. $67,000 to $69,999	0.3
w. $70,000 or more	1.0

2. Your raise during the past year was ...

a. None	10.3%
b. Less than 2%	2.1
c. 2 thru 5%	26.9
d. 6 thru 9%	38.9
e. 10 thru 13%	11.5
f. 14% or more	4.4

3. How long have your worked for your present employer?

a. Less than 1 year	4.2%
b. 1 thru 3 years	17.5
c. 4 thru 6 years	18.3
d. 7 thru 9 years	11.8
e. 10 thru 12 years	8.9
f. 13 thru 15 years	7.6
g. 16 thru 18 years	8.6
h. 19 thru 21 years	6.4
i. 22 thru 24 years	5.3
j. 25 thru 27 years	4.4
k. 28 thru 30 years	2.9
m. 31 thru 33 years	2.4
n. 34 thru 36 years	0.8
o. More than 36 years	0.9

4. What is your age?

a. Under 26	2.7%
b. 26 thru 30	11.2
c. 31 thru 35	16.0
d. 36 thru 40	16.8
e. 41 thru 45	15.6
f. 46 thru 50	12.2
g. 51 thru 55	11.9
h. 56 thru 60	8.3
i. 61 thru 65	3.9
j. Over 65	1.1

5. How many years of experience do you have?

a. Less than 1 year	0.5%
b. 1 thru 5 years	13.1
c. 6 thru 10 years	17.8
d. 11 thru 15 years	16.0
e. 16 thru 20 years	13.9
f. 21 thru 25 years	13.5
g. 26 thru 30 years	11.4
h. 31 thru 35 years	8.8
i. 36 thru 40 years	2.8
j. More than 40 years	2.0

6. What is the highest degree you hold?

a. Less than bachelor	7.3%
b. Bachelor	36.5
c. Master	25.5
d. Doctorate	30.8

7. What is your profession?

a. Chemist	37.8%
b. Chemical engineer	6.6
c. Mechanical engineer	9.6
d. Electrical engineer	10.3
e. Aeronautical engineer	1.2
f. Industrial engineer	1.3
g. Physicist	8.6
h. Metallurgist	5.3
i. Biolgist	5.4
j. Mathematician	0.6
k. Ceramist	1.6
m. Geologist	1.2
n. Other	10.6

8. Do you work in ....

a. Industry	72.8%
b. Government	16.6
c. University	10.6

9. Are you ....

a. Male	93.7%
b. Female	6.3

R&D

OPINION POLL RESULTS

Technology should assist, not replace, older industry

THE SO-CALLED smokestack industries should be retained and high technology should help them to modernize, say the nearly 2,000 respondents to our recent poll on this subject.

The poll followed an Editorial in which we quoted Ian M. Ross of Bell Labs and Roland W. Schmitt of GE on the subjects of reviving the present industries *vs* replacing them and on the seriousness of foreign competition.

Readers were nearly unanimous (96%) in agreement with Ross about the application of technology to the solution of industry's woes. Complete results of the survey follow.

1. *Do you believe that we need to retain the so-called smokestack industries in some form?*
   a. Yes ... 89% b. No ... 7% c. No opinion ... 4%

2. *Do you agree with Ross that we need to use high technology to upgrade the basic industries?*
   a. Yes ... 96% b. No ... 3% c. No opinion ... 1%

3. *Would it "be economically healthier for states and municipalities to try to upgrade present industry than to try to attract high technology?"*
   a. Yes ..... 23% b. Yes, usually 9%
   c. Rarely ..... 62 d. No. 6

4. *Ross says that upgrading any state's economy will depend on "improving the educational system which must supply its most important resource—creative and skilled people." Do you agree?*
   a. Yes ... 91% b. No ... 7% c. No opinion ... 2%

5. *He declares that improving education will require "a national movement that is effected at the state and local level by a people who understand the importance of education." Do you agree?*
   a. Yes ... 88% b. No ... 9% c. No opinion ... 3%

6. *In the same Editorial, Schmitt is quoted, "The Japanese ... are competent, skillful, aggressive competitors who win commercial victories with the same armaments that are available to us." Do you agree?*
   a. Yes ... 74% b. No .. 22% c. No opinion ... 5%

7. *And Schmitt adds, "In many ways our strengths are greater than theirs," citing our entrepreneurial climate, our free market system, and research universities. Do you agree?*
   a. Yes ... 75% b. No .. 17% c. No opinion . 8%

8. *Do you study such subjects as these ...*
   a. Regularly 23% b. Fairly often 61% c. No 16%

9. *What is your principal resource?*
   a. Newspapers . 21% b. Magazines 68%
   c. Books ..... 7 d. Television 2
   e. Speakers ..... 1 f. Friends 1

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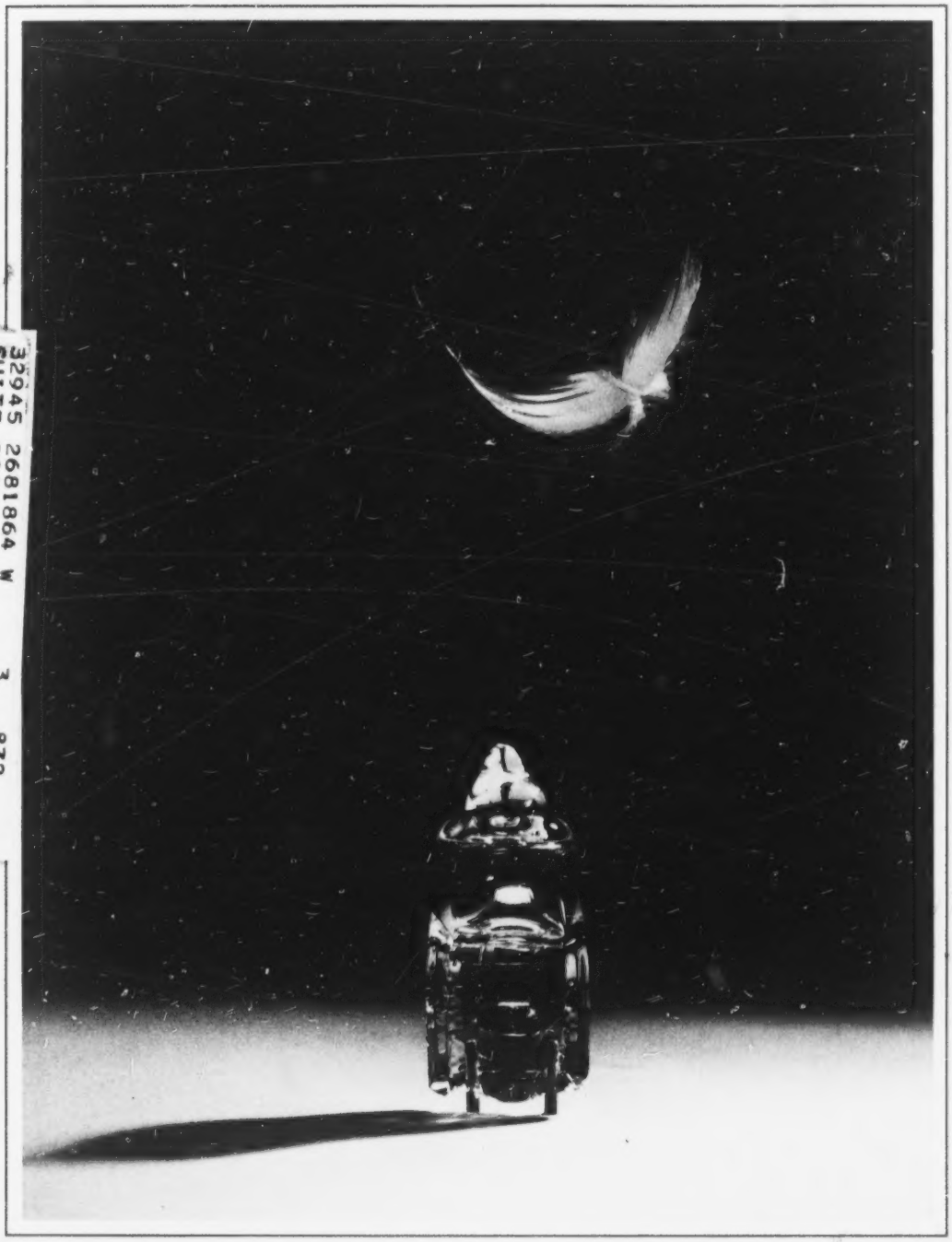

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News of importance to people who work in research, development

Chromatography developments and applications

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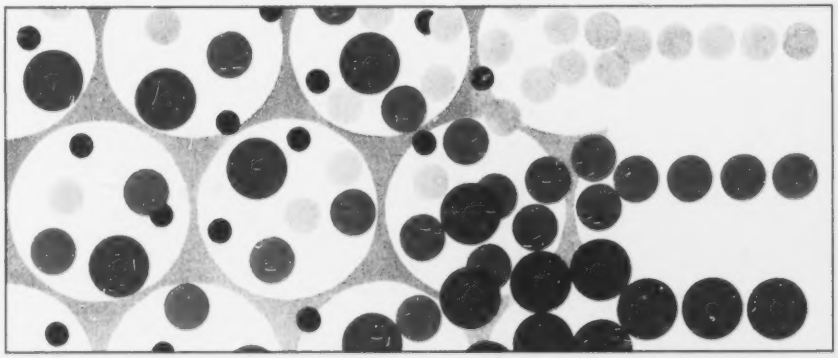
New solutions to separations problems. See pp 90, 96, 104, 116.



EDITORIAL

11 Let's get R&D off the ground

DEPARTMENTS

19 Innovative notebook
25 Product development
31 A lawyer's view
39 Research trendletter
43 R/D news in brief
131 Vacuum technology
139 Bookshelf
147 New products
161 R&D product center
167 Literature
187 Opinion poll results
188 Opinion poll questionnaire
192 2020 Vision
194 Letters
197 Advertisers index
199 Reader service card

ABOUT THE COVER

The most efficient use of space in modern analytical instruments has required the development of smaller and smaller light sources and—frequently—lower voltages. At the same time, the small sources have to retain high and constant illumination.

One answer to this problem is a subminiature halogen lamp from Gilway Technical Lamp, Woburn, MA. Although this 6-V lamp is only 8.5 mm dia., it develops a color temperature of 3200 K while consuming only 1.6 A. The lamp sells for less than $5 (feather not included).

NEWS

49 Space: U.S. is stumbling in space race; component decisions shape the future of particle beam fusion; USAF contentions are proven in *Discovery* mishap; tiny semiconductor isolates electron noise

52 Science policy: Officials iron out differences over tech export controls as other issues arise; Bulgaria's case exemplifies policy contradictions

56 New developments: U.S. Army licenses welding and rust control innovations

58 Electronics: Material extends the capabilities of IC processing equipment; British work to improve electron-beam machine throughput

62 Conferences: Isaac Asimov, materials issues highlight Semicon East '84; UK researchers improve sonic level gage

68 Physics: Quark discovery fills out lowest level of matter; scientists begin anew their quest for magnetic monopoles; Australia upgrades heavy ion accelerator

74 Aviation: Advanced materials and design aid quest to circle globe unrefueled

79 Nondestructive testing: Boeing uses medical CT scanners to inspect IUS parts

83 Environment: Recent events shake earthquake prediction theories

85 Conservation: Vacuum distillation key to waste oil recovery process

ARTICLES

90 GPC distinguishes useful and non-useful polymer compositions: John Helfrich and Mark Andrews, Waters Assoc.; GPC for polymer quality assurance and product testing.

96 Indirect photometric detection in anion chromatography: Pamela Perrone and J. Russel Gant, Perkin-Elmer Corp.; reversed-phase ion pairing and indirect photometric detection offer alternative.

104 Detector for GC works in far UV: J.N. Driscoll, B. Towns, and P. Ferioli, HNU Systems Inc.; the combination of far UV with photoionization.

110 High-level language with RISC support makes a fast super mini: Robert Ragan-Kelley, Pyramid Technology Corp.; maximum capability use by reduced instruction set computers.

116 Let's see what's coming in separation technology: H.L. Thomas, associate editor; field-flow fractionation joins standard separation methods.

124 Ultrasonic nozzles take pressure out of atomizing processes: Harvey L. Berger, Sono-Tek Corp.; no clogging, overspray waste, or excessive wear.

131 Cryopumps fill linac vacuum needs: R. Donald Biron, MIT Bates Linear Accelerator; new vacuum system meets tough specs for increased energy output.

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OPINION POLL RESULTS

Shuttle, spacelab hold important potential for R&D

THE SCIENTISTS and engineers who read this magazine see important applications for research which could be done in space. And, four out of every five of them would go into space to do the research. That is true if the nearly 1,900 respondents to our recent survey on this subject are representative of our readers.

More than half of the respondents believe that there could be at least a little advantage to their research from present shuttle programs. Nearly a fourth of the respondents expect a lot of advantage.

Looking at the possibility of introducing new programs to the shuttle flights, 71% of the respondents believe that their research might benefit. Included in that figure are 26% who believe that more than one research program could be done in space to advance their special needs, and 14% say that there are many such programs as far as their work is concerned.

Complete results of the survey follow:

1. *Do you see any potential advantages for your research from present shuttle programs?*
   a. A lot ..... 23% c. Doubtful 20%
   b. A little ..... 33 d. No 23

2. *Are there space research programs that could be done on the shuttle that would be helpful to your research?*
   a. Yes, many ..... 14% c. Perhaps 31%
   b. Yes, a few ..... 26 d. Probably not 29

3. *Does materials processing in a weightless environment hold any potential for your research?*
   a. Yes .... 21% b. Possibly ... 35% c. No ... 45%

4. *Do life sciences tests in weightlessness hold any potential for your research?*
   a. Yes .... 10% b. Possibly ... 24% c. No ... 66%

5. *Does research above Earth's atmosphere have potential for your studies?*
   a. Yes .... 23% b. Possibly ... 35% c. No ... 42%

6. *Does exposure to cosmic rays or continuous insolation have advantages for your research?*
   a. Yes .... 12% b. Possibly ... 27% c. No ... 61%

7. *Could your field of research be advanced significantly by having a scientist at work on a space station?*
   a. Yes ..... 16% c. Possibly 35%
   b. Probably ..... 16 d. No 33

8. *If you were given the opportunity, would you fly in the space shuttle to pursue your research?*
   a. Yes ..... 52% c. No 23%
   b. Probably ..... 17 d. No way! 8

9. *If you were given the opportunity, would you work in a space station to pursue your research?*
   a. Wow! Would I! ... 53% c. No 21%
   b. If necessary 26

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